POWER PLANT ENGINEERING

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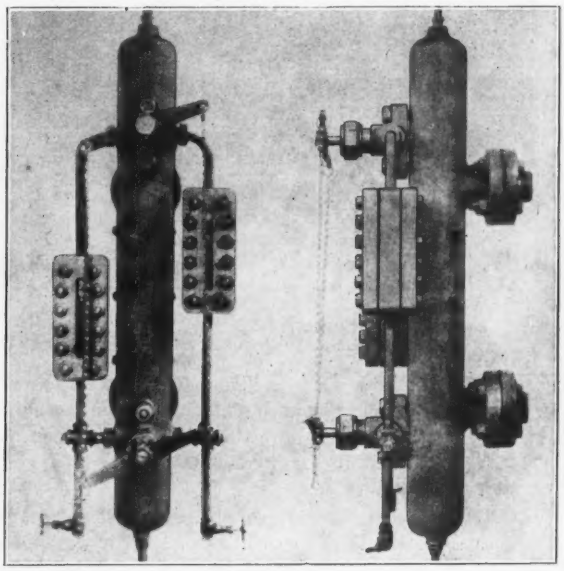
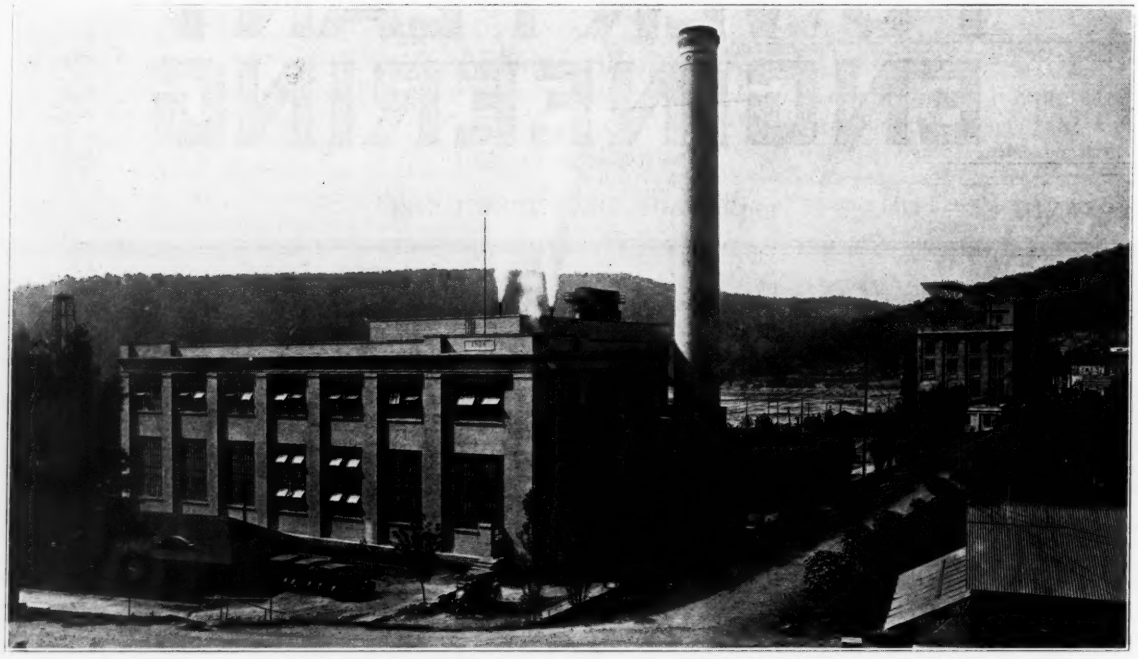


600 Fathoms Down

DURING THE course of a storm on the ocean or on the lakes have you ever wondered whether the glass in the port holes would stand up under the seemingly irresistible force of the breaking waves? If you have been a bit dubious about the use of glass for such a purpose, just consider the service under which gage glasses for 1200 lb. boilers must operate. The one pictured above, and described in detail in the article on page 1191, has been operated at 1600 lb. pressure and the glass is only 0.7 in. thick. So why worry about the port holes? On this basis your ship could sink 600 fathoms, 3600 ft., and you could observe the scenery on the way down—provided, of course, the water didn't run under the stateroom door.

IT SEEMS PARADOXICAL that in the modern generating station with all its facilities for producing electrical energy on a large scale, designers should be puzzled as to where to get the electrical energy necessary to run the motor driven auxiliaries. It is the old case of "Water, water everywhere—" changed to "electricity, electricity everywhere but not an ampere to use." On page 1204, however, you will find an article which tells what modern practice is in this respect.



Hales Bar Steam Plant on the Tennessee River

TENNESSEE ELECTRIC POWER CO. IS INSTALLING THE SECOND 25,000-KV.A. UNIT IN A NEW STATION ADJACENT TO A HYDRO PLANT. BY LOUIS R. LEE*

EARLY IN 1912 the Tennessee Electric Power Co. began operations in Tennessee and having had a steady growth since that time, has found it necessary and economical to provide additional steam and hydro-generating facilities. In the beginning these steam-generating plants were located in the larger cities but in 1916 it was found desirable to build a steam plant adjacent to Ocoee No. 1 hydro plant. This has proven extremely successful and economical. It was built for low first cost and its operating cost has been low because it has operated in conjunction with the hydro station. The Hales Bar Steam Plant is another plant similarly located.

In designing the Hales Bar plant two important factors, having to do with local conditions, have been taken into account. First, low annual load factor requiring low investment per kilowatt capacity. Second, high operating period load factor making it economical to provide equipment that would give high thermal efficiencies. Consideration has also been given to advances in the art of steam generation and a selection has been made of a normal high pressure and superheat, also using the idea of interstage feed water heating but still retaining the use of the economizer. There also seems to be a possible economy in the preheating of air for the furnace and that idea is also incorporated in the design.

This plant is located on the Tennessee River about 20 mi. below Chattanooga and great quantities of high-grade coal are available in the vicinity so that the plant is practically a mine-mouth plant. It is constructed adjacent to a 45,000-kw. hydroelectric plant where it has been possible to take advantage of many existing facilities such as operators' village, hydro dam for circulating water supply, railroad connections, river navigation, real estate, transmission lines and substation facilities.

In the general design of the plant itself some features are worth special notice. The ground plan is compact but all heavy equipment including the chimney is set on concrete foundations which rest on a concrete mat 30 in. thick, the earth under the mat being uniform clay hardpan. The main floor elevation is 653 ft. above sea level and is well above any known high water. The elevation of the crest of the hydro dam is 636 ft. above sea level.

Building construction is of steel frame type with curtain walls of buff colored exterior and red interior brick, the buff color blending well with the concrete hydro plant construction. The interior wall surface will be painted. Steel window sash and doors are used. The roof is reinforced concrete with suitable asbestos sheet and asphalt waterproofing and copper flashing. The entire building is therefore of permanent fireproof construction.

COAL IS BROUGHT TO THE PLANT BY BARGES

Coal is received at the plant by river barge and by standard gage railroad cars. The plant itself is located immediately below the dam and the river barges dock in the forebay and the coal is taken from them by means of an overhead electric grab bucket cableway. The grab bucket may be discharged into the plant track hopper or into the seasonal outdoor coal storage, or may take coal from seasonal storage and deposit it in the track hopper. Coal coming in by railroad cars may be discharged into track hoppers or into one or two concrete pits along the elevated track. A drag line scraper removes coal from these pits and places it in storage in uniform layers. This storage is of sufficient size to carry a five months' coal supply.

*Chief Eng., E. W. Clark Engineering Corp.

Power is generated at 13,200 v., 60 cycle, 3-phase and is immediately stepped up to 120,000 v., which is the voltage of the main transmission system. The plant design is for an ultimate 100,000 kw.; there are now two 20,000-kw. General Electric Co. turbo generators installed. Steam pressure is 386 lb. gage at boiler relief valves and superheated to 725 deg. F. One turbine is provided with a C. H. Wheeler Mfg. Co. surface condenser and the other with a surface condenser made by the Wheeler Condenser & Eng. Co. Both surface condensers are of sufficient size to give 2 in. abs. of mercury back pressure during average summer conditions and 1 in. abs. of mercury back pressure under cool weather conditions. The plant carries out the unit design in both boiler and turbine plants. The boiler units are designed for an economical capacity of 8000 kw. and each consists of one 10,752 sq. ft. Babcock & Wilcox Co. cross-drum type boiler.

Each boiler is equipped with one 2000-sq. ft. interdeck Babcock & Wilcox Co. superheater; one eight-retort Riley superstoker provided with double roll clinker grinders; one 7500-sq. ft. vertical cast-iron tube, 250 lb. pressure Green economizer; one horizontal tube type Green Fuel Economizer Co. air preheater; one Green steel-plate, single-inlet, induced draft fan; one Green radial flow type double-inlet forced draft fan; one Lecourtenay Co. double-section 8-stage motor-driven centrifugal feed pump; Copes regulators; Engineer balanced draft and a Bailey steam flow meter.

It is interesting to note that the feed pump is built in two sections, the first section receives water from Wheeler Condenser & Eng. Co. extraction closed heaters at approximately 25 lb. pressure and 210 deg. F. and supplies this water to the economizer at a maximum of 250 lb. pressure. The second section of the feed pump receives water at approximately 250 lb. pressure at a maximum of 350 deg. F. and supplies the boiler at 390 lb. pressure. The pressure discharge of each section of this feed pump is controlled by Fisher regulators. These pumps are provided with bronze casings and impellers and have a capacity of 350 gal. per min. and are driven by 200-hp. General Electric Co. 1800-r.p.m. synchronous speed, 2300-v. induction motors.

Economizer Soot Pits Are Connected to Boiler Ash Pits

Green Fuel Economizer Co. economizers are of the baffle type arranged as a compact unit immediately back of the boilers and about 8 ft. above the main floor. A soot pit under each economizer connects directly with the ash pit of the boilers so that all soot or ash from the economizer may be removed by the ash conveyors. Boilers and economizers are cleaned with steam by means of Diamond mechanical soot blowers; there are six units on each boiler and five units on each economizer. The air heater is cleaned with a hand lance using compressed air. Each boiler unit is provided with a fire brick-lined concrete ash pit having 2673 cu. ft. or a capacity of about 60 T. This is sufficient to care for full operation of the unit for 85 hr.

For driving the Riley underfeed stokers, a 20/6-hp. variable speed motor is provided, chain belt connected to an extension shaft from the two-speed gear boxes.

Coal is supplied to the boiler units by means of a Jeffrey Mfg. Co. overhead electric traveling weigh larry. This larry has a capacity of 20,000 lb. and carries sufficient coal to fill the hoppers on three boiler units, or all units on one side of the boiler room. A similar larry will

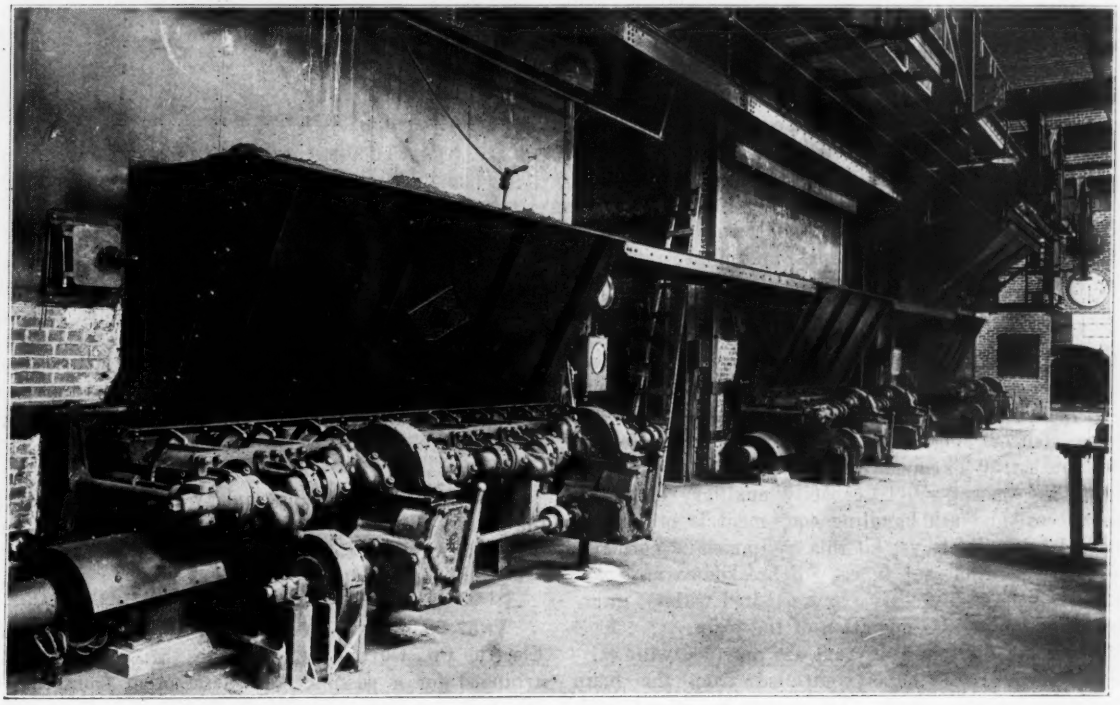


FIG. 1. THREE 10,762 SQ. FT. CROSS-DRUM BOILERS HAVE BEEN INSTALLED. EACH BOILER IS EQUIPPED WITH A SUPERHEATER, AN ECONOMIZER, AN AIR PREHEATER AND AN UNDERFEED STOKER. COAL IS DISTRIBUTED BY A WEIGH LARRY

be provided for the opposite side of the boiler room. These larries will receive coal, without leaving the boiler room, by chutes coming through the end wall of the boiler room, which are in turn fed by silo-type coal tanks on the outside of the building or by elevators in emergency. One 500-T. capacity silo tank carries sufficient coal for the operation of three boiler units at maximum capacity for a period of about 24 hr. It is expected that this coal storage capacity will allow continuous operation of the plant at a high load factor while using a week day coal handling crew on a 10-hr. shift.

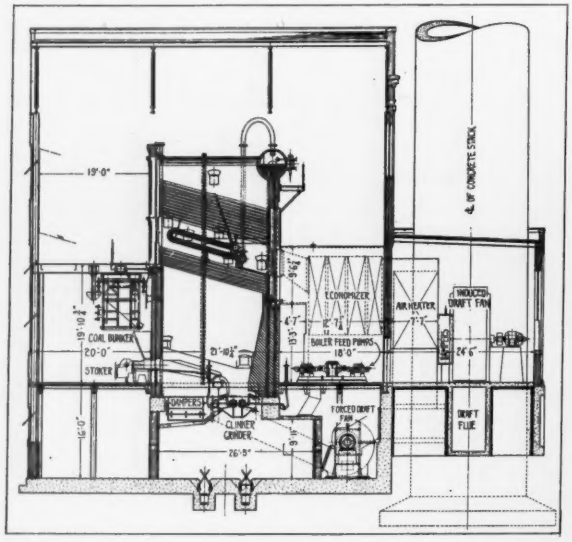


FIG. 2. EACH SUPERHEATER CONTAINS 2000 SQ. FT. OF HEATING SURFACE AND IS OF THE INTERDECK TYPE

Ash is removed from the ash pits by duplicate Jeffrey manganese-steel horizontal drag-chain conveyors. The ash is dumped through cast-iron gates onto these drag chain conveyors, the drag chain discharging into a Jeffrey skip hoist at the end of the station. The skip hoist empties into an overhead concrete-lined steel ash tank which has a capacity of about one railroad car. Ash will be removed from the plant by means of railroad cars and used for railroad grading. Each ash conveyor has sufficient capacity for removing all ash from full ash pits in a period of about 12 hr.

Coal Is Stored in Silo-Type Bunkers

Coal handling equipment for six boiler units will consist of two 500-T. capacity silo-type coal bunkers; one 150-T. double-track railroad car hopper, duplicate 50-T. capacity Jeffrey single-roll crushers; duplicate Jeffrey pivoted bucket 50-T. capacity coal elevators and duplicate Jeffrey "V" bucket, 50-T. capacity auxiliary elevators. Thus all coal and ash handling equipment is practically furnished in duplicate yet all this equipment is normally in regular operation but in case of breakdown any part may be dropped out of service and repaired without interfering with the regular operation of the plant.

Forced and induced draft fans are provided with variable speed motors, hand controlled from the main boiler room operating floor. The motors on forced draft fans are direct connected and those on the induced draft fans are connected by a chain belt drive with a reduction ratio of two and one-half to one. The induced draft fans discharge downward at an angle of about 45 deg. into a concrete flue, which in turn discharges into the base of the 175 by 14 ft. concrete stack. It is interesting to note that the induced draft fans and air heaters are housed in a low structure at the side of boiler room. The furnace air supply is taken from the main boiler room through openings into the induced draft fan bay and drawn through air heaters by the suction of the forced draft fan. In this way such heat as may be accumulated in the boiler room and fan room is used to raise the temperature of the air supply to the heaters.

Design of the heaters is such that some research work will be necessary to see what will be the best arrangement of tubes and whether the tubes shall be of cast iron or steel. It is possible to obtain a much greater surface by the use of steel tubes and if draft loss is not too great and

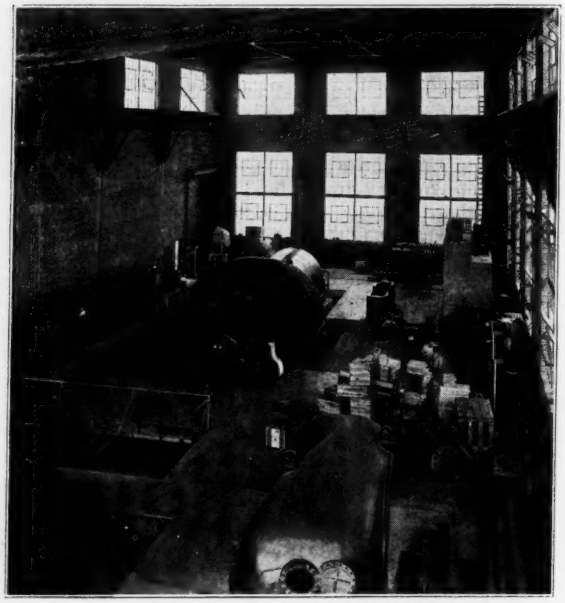


FIG. 3. ONE 20,000-KW. TURBINE UNIT HAS BEEN COMPLETELY INSTALLED. A SIMILAR UNIT IS NOW BEING ERECTED

if deterioration of the steel tube does not seem to be serious it is probable the steel tube will be used on all units. The economizers are entirely asbestos insulated and steel encased. The boiler side walls are set with fire brick with exterior of walls of hard burned red brick. The front wall is steel encased solid fire brick and the back or bridge wall carries a heavy sloping fire brick face with exterior of hard burned red brick. The air heaters are also steel encased.

The larry track is supported by steel work just below the bottom row of boiler tubes, this steel structure forming a platform for the care and repair of boilers.

Steam Can Be Extracted from Three Stages

Two 20,000-kw. 25,000-kv.a., 1800-r.p.m. General Electric Co. Curtis-type, 14-stage turbo-generators, are arranged for a possible steam extraction from the 3rd, 7th and 11th stages, arrangements being made at present to extract steam regularly from the 7th stage for evaporation of make-up and for heating of make-up and con-

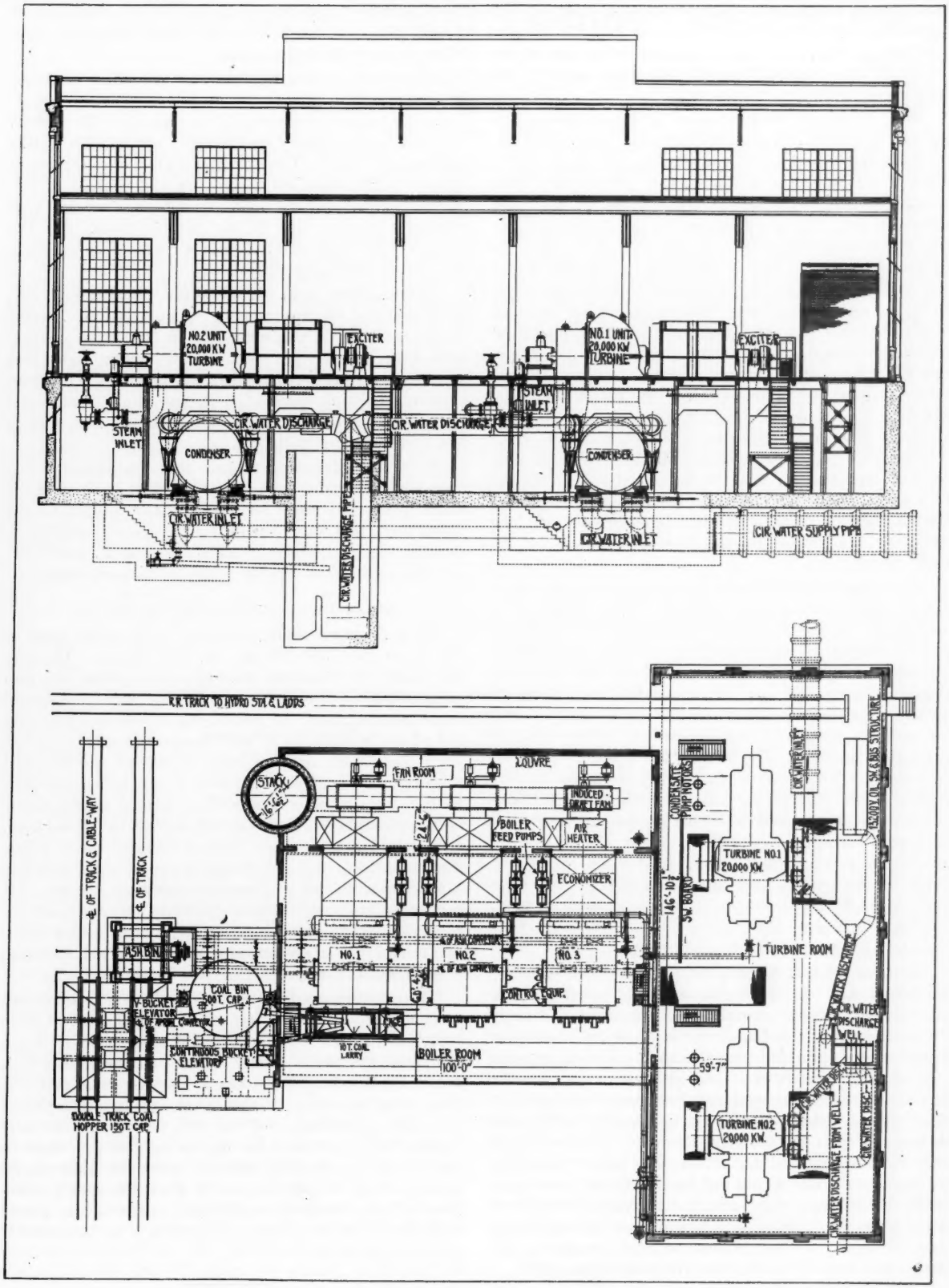


FIG 4. IN THE UPPER DRAWING IS SHOWN THE ARRANGEMENT OF THE WATER SUPPLY TO AND FROM THE CONDENSERS. THE LOWER DRAWING SHOWS THE RELATIVE POSITION OF THE COAL AND ASH HANDLING SYSTEM WITH RESPECT TO THE MAIN UNITS

densate to a temperature of approximately 210 deg. F. There is a connection to the 3rd stage so that the Wheeler Condenser & Eng. Co. evaporators may be operated in an emergency at approximately 120 lb. gage pressure for more rapid production of make-up.

Total surface of the condensers is approximately 34,000 sq. ft. of 1 in., 18 gage Muntz metal tubes which are expanded into one 1½-in. tube sheet at the return water box and are packed in a 1½ in. tube sheet with Crane metallic packing with bell mouth ferrules on the inlet water box end. These condensers require 40,000 gal. per min. circulating water and are provided with duplicate inlet and outlet circulating water piping so that either half of the condenser may be cleaned while in operation. Duplicate ejector-type steam vacuum pumps are provided as are duplicate vertical 2-stage centrifugal motor-driven condensate pumps of 500-g.p.m. capacity. Water comes into the turbine room through a tunnel from the forebay through duplicate traveling-belt type Chain Belt Co. screens. The condensers are set with the highest point of their water compartments at elevation 645.5 which requires that water be siphoned through from the dam crest at elevation 636. The condenser water is discharged into a sealing well, in the turbine room basement. It then discharges through a 5 ft. diameter, 650 ft. long discharge line which empties into the tailrace of the hydro plant.

Heaters and evaporators are provided in a double unit, for the two turbines now installed. Each consists of a two effect evaporator plant and an evaporator condenser and an extraction condensate heater. The condensate is pumped through the turbine, radojet inner and after condenser, General Electric Co. generator air cooler, oil cooler, evaporator condenser and extraction heater, so that all available waste heat is taken care of before using the extraction heating. The evaporator plant is therefore essentially a low pressure plant using steam at approximately 20 lb. gage pressure at full load on the turbines. A cold water surge tank is floated on the condensate line at approximately the discharge pressure (30 lb.) of the condensate pump so that during light loads on the turbines the water will automatically flow from the surge tank through the coolers and heaters to the feed pump suction. The surge tank is kept filled to capacity as the demand at the suction of the feed pump varies.

Suitable oil switches connect the two 20,000-kw. turbines to a bank of three 16,666-kv.a., single-phase, 13,200-v. delta, 125,000-v. star-connected water-cooled General Electric Co. core type transformers. A single phase spare transformer is provided with this bank. The high voltage side of this transformer is provided with rather unusual tap arrangements by means of which power is supplied to the Tennessee Electric Power Co. system at 125,000 v. and is received from the Alabama Power Co. system at 100,000 v., the combined output of this transformer from regular transformer action and by auto transformer action being 75,000 kv.a. Of course, the operation of the transformer may be reversed so that power may be transmitted into the Alabama Power system, depending upon the demand and capacity of the line available at this point.

All auxiliaries in this plant are motor driven with the exception of the ejector type vacuum pumps. All auxiliary motors are either 2300 or 440 v., 3 phase and 60-cycle. Duplicate 1750-kv.a., 3-phase, 6600 to 2300 and 440-v. auxiliary transformers located in the basement of the turbine room receive power at 6600 v. from the main 6600-v. bus of the hydro plant.

All control wiring, lighting and excitation is at approximately 220 v., the excitation being furnished by 250-v. direct connected exciters and the control at 220 v. from a storage battery located in the hydro station. All station lighting is at 220 v. The electrical control of the station is located on the main operating floor and consists of two control pedestals for the main turbines with pedestal type regulators on one side of the turbine room. On the opposite side of the turbine room a board of 20 panels is provided for auxiliary control.

In the turbine room is a Cleveland Crane & Eng. Co., 60 T. overhead electric traveling crane, 57 ft. 7 in. center to center runways, maximum lift 50 ft. It is provided with a main hoist of which the maximum light load operating hoisting speed is 16 ft. per min. and a full load operating hoisting speed of 8 ft. per min. Bridge and trolley travel with light load is 100 ft. per min. and at full load 50 ft. per min.

It is also interesting to note that the filtered transformer cooling water from the hydro plant is piped to the steam plant and used for the make-up supply to the evaporators, this water having an average temperature in summer operating season of about 150 deg. F. after cooling the ejector type vacuum pump on the evaporators.

Steam Piping is Designed for 600 lb.

All main steam piping is designed for a maximum of 600 lb. pressure and 750 deg. F. temperature. The piping joints are Vanstone and all steam joints are provided with corrugated Monel metal gaskets and special high strength bolts. All covering is 85 per cent magnesia and of ample thickness to provide against undue heat loss from these high temperatures. Wherever possible and practical welded nozzles and welded pipe have been used. In feed lines or other places where welded nozzles might seem undesirable special cast steel fittings have been used, a special effort being made to avoid all unnecessary joints. The main steam piping is anchored and provided with one expansion bend and long sweep connections are provided to the turbines so there is a minimum possibility of expansion strains on main boiler outlets and turbine throttle connections. Low pressure water lines are provided, where necessary, with copper expansion joints.

In the entire construction of this plant every effort has been made to secure the best grade of equipment and the best material but equal effort has been made to use a minimum amount of material and equipment and thus secure the result desired so as to keep the total cost low. The entire operation of this plant can be accomplished from the main floor. All coal and ash are mechanically handled with provision for storage so that they may be handled during weekday daylight hours, the seasonal coal storage being of such size as to allow the supply taken from mines of relatively small daily capacity. The annual load factor of the plant will probably be considerably below 50 per cent.

Keep the boiler or power plant clean and neatly painted. Cleanliness in a plant promotes pride, and pride in one's work means better and more careful work.

Tendencies in Steam Turbine Construction

TROUBLE IS NOT ANTICIPATED WITH OPERATING PRESSURES AS HIGH AS 1200 LB. TEMPERATURES WILL NOT GO ABOVE 750 DEG. F.

PROGRESS IN THE design of the steam turbine has resulted from the close co-operation between the builders of turbines and the power companies who produce and distribute power. The producer of power has been constantly reaching out for larger and more efficient equipment. It has been required of the turbine builder not only to meet this demand but also to anticipate it and thus offer improvements ahead of the demand. The importance of this subject is indicated by the fact that at the recent World Power Conference in London Francis Hodgkinson and Sir Charles A. Parsons presented excellent papers on steam turbines.

Thermal efficiency of a heat engine depends chiefly upon temperature range. This is in accordance with Carnot's principle, which states that the temperatures at which heat is supplied and withdrawn should be as widely separated as possible. A wide temperature range must necessarily be accompanied by a wide pressure range. Accordingly, the expansion ratio in modern steam turbine practice is being constantly increased as is shown in turbines under construction wherein the ratio is in the neighborhood of 1500 to 1. The corresponding temperature range is from about 470 deg. F. saturation temperature, raised to 750 deg. F. by superheating, down to about 75 deg. F., or a maximum drop of about 675 deg.

Progress in the direction of increasing the thermodynamic value of the heat in the steam without unduly increasing the maximum temperature, is being made by increasing the mean temperature of heat reception. One method of effecting this is the adoption of regenerative feed water heating, by using steam drawn off from various stages of the turbine. A second method of increasing the mean temperature of heat reception would be that of superheating to the maximum temperature in order that further heat might be added so as to maintain isothermal expansion throughout the initial stages of the turbine. Reheating has the advantage of greatly extending the range within which superheat exists and of diminishing the range where moisture and the resultant loss by water resistance or increased viscosity exists. Still another method of attacking the same problem is to increase the mean temperature of heat reception by increasing the boiler pressure.

If we consider a boiler pressure of 250 lb. per sq. in. and a final temperature of 750 deg. F. after superheating and a feed water temperature of 79 deg. F., the mean temperature of heat reception will be about 360 deg. F. If the boiler pressure is increased to 2000 lb. per sq. in. and the steam is still superheated to 750 deg. F., then, since the latent heat is received at the increased temperature of the boiler, the mean temperature is increased to about 480 deg. F. If we further assume that the water is fed into the boiler at the boiling temperature, the mean temperature of heat reception is increased to 680 deg. F.

LAST ROW OF BLADES IS IMPORTANT

High generator capacities and high vacua have become so common that the design of the steam path is largely concerned with the last rows of blades. The high pressure range problem has become easier because of the increased volume of high pressure steam now used. At present the tendency is to do away with the practice of operating the two elements of cross-compound turbines individually, preference being given to regarding them as single units. Operators have had some misapprehension regarding this type of machine because of switchboard complication. This has no foundation, however, because the generators are coupled electrically and thus become in effect a single winding divided into two or more parts.

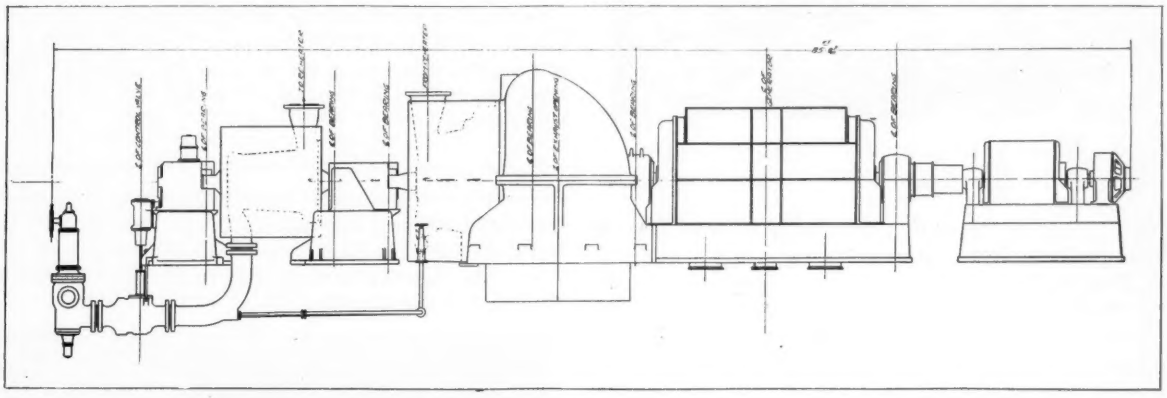


FIG. 1. OUTLINE OF A 40,000-KW., 1800-R.P.M. TANDEM COMPOUND TURBO-GENERATOR

Low blade speeds have the great advantage of small velocity components parallel to the turbine axis. They therefore result in lower leaving losses. This is a feature of the two-speed cross-compound turbine, as the design may be carried to the extreme of low rotative speed of the low pressure element. This permits any desired degree of low leaving loss without a sacrifice of efficiency in the high pressure ranged of the turbine.

Exhaust chamber of the turbine has received a great deal of attention with the object of diminishing eddies and pressure drop. This would seem as desirable as similar developments in hydraulic turbines and as important as the form of inlet passages to blowers and centrifugal

pumps. Some machines are provided with diffusing passages from the blades to the turbine outlet. These give an additional advantage of distributing the exhaust steam equally over the entrance to the cooling surface of the condenser.

Steam Bleeding Shows Marked Economies

Large turbine builders are now making provision for bleeding the turbine for stage feed water heating. This

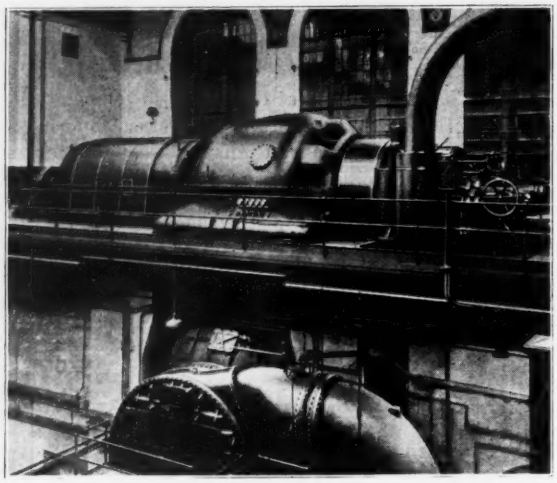


FIG 2. RECENT INSTALLATION BY ALLIS-CHALMERS OF A 20,000-KW., 1800-R.P.M. TURBINE AND GENERATOR

effects a considerable saving over the practice of heating by the exhaust from steam-driven auxiliaries.

Bleeding has the effect of reducing congestion in the extreme low pressure blading. As an example, a turbine heating its own feed in two stages, say at 145 deg. F. and 205 deg. F. will require about 4.1 per cent more steam supplied at the throttle. This same turbine, however, will deliver about 7.5 per cent less steam to the condenser than if regeneration by feed heating were not used. In this way either lower terminal losses will be permitted or a correspondingly higher rating of the turbine may be had.

In recent practice surface type generator air coolers are being employed. Their use has resulted in the advantages of less dirt in the generator windings and less oxygen present to support combustion in case of generator trouble. Condensate is sometimes used for cooling the air. Combinations in which both condensate and raw water are used are sometimes employed. In this manner a large proportion of the generator losses may be absorbed by the feed water. The actual gain, however, is not great if the feed is also heated by bleeding the turbine because of the generator losses being added to the feed water, thus reducing the amount bled at the lowest stage.

In order to obtain assurance of the homogeneity of the material of disks and their freedom from internal defects, one large turbine builder has applied the principle of "magnetic analysis." This method makes use of a strong magnetic field which is passed laterally through the disk, the searching coils covering a small area at a time until the entire surface has been explored. Variations of magnetic resistance effect currents in a coil which are recorded on a chart.

Erosion of turbine blading shows plainly that the moisture in a turbine occupies the outer zone of the steam path. Therefore machines of late design are arranged with adjacent edges of the blade rings brought close together so that the velocity of the steam going to the heater at full load is about 150 ft. per sec. It is believed that in this construction some of the moisture will be carried away when the turbine is operating with full flow to the feed water heaters.

Large Turbines Rest Directly on Foundations

Bedplates do not add to the stability of a unit and therefore they have been eliminated. The turbine elements are bolted directly to seating plates which form the upper surface of the foundations which may be either of concrete or of structural steel.

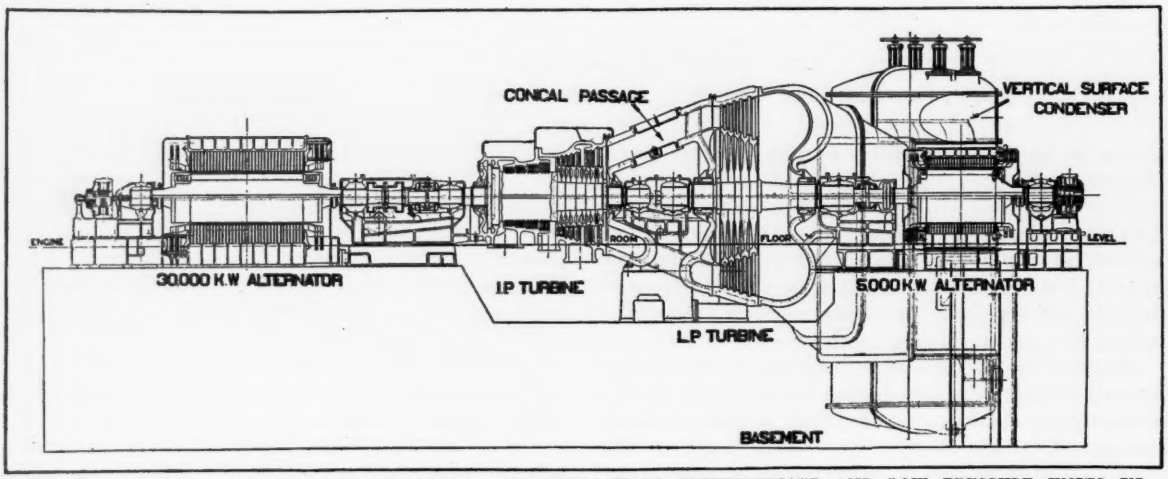


FIG. 3. ENGLISH BUILT UNIT FOR CRAWFORD AVE. WILL HAVE INTERMEDIATE AND LOW PRESSURE UNITS IN ONE CASING BUT ON SEPARATE SHAFTS

One installation of particular interest comprises three 50,000-kw. turbines, which are being installed for the base load station of the Commonwealth Edison Co. at Crawford Ave., Chicago. The operating conditions will be 550 lb. steam pressure and 725 deg. total temperature. The steam will expand through the high pressure turbine elements, then it will be reheated to 700 deg. and returned to the low pressure turbine elements. Each turbine unit is being built by a different company. All will be cross-compound

turbines. One, a 60,000-kw. turbo-generator, was built by the General Electric Co., in which a separate high pressure, 1800-r.p.m. generating element will, at full load, expand steam to 120 lb. absolute pressure, at which it is reheated; the steam is then returned to a single low pressure, 1200-r.p.m. turbine expanding to the condenser pressure.

One Unit Was Made in England

The second unit was made in England by C. A. Parson & Co. It is a 50,000-kw. unit with a high pressure, 1800-r.p.m. generating element which, at full load, will expand steam from the initial pressure to 115 lb. absolute. The steam will then be reheated and returned to the lower pressure elements of the two-speed tandem type turbine. These elements operate at 1800 and 720 r.p.m. respectively.

The third turbo-generator, a 50,000-kw. unit, is being built by the Westinghouse E. & M. Co. The high pressure and intermediate stages are arranged as a tandem compound, 1800-r.p.m. machine. At full load, the high pressure expands to 132 lb. absolute, at which pressure it is reheated and returned to the intermediate turbine element where, at full load, it is expanded to 16½ lb. absolute. It then passes to the low pressure element and drives a separate generator.

One penalty of reheating is a complexity of regulating apparatus because the steam in the reheater and its piping would be sufficient to cause overspeeding if the turbine should be relieved of its load. At the Crawford Ave. installation, each of the three manufacturers has adopted a different method of handling this matter. That adopted by the Westinghouse E. & M. Co. provides that the inner range of the speed-responsive device operate the single valve controlling steam to the turbine and as the governor

FIG. 4. SINGLE-CYLINDER INSTALLATION BUILT BY THE GENERAL ELECTRIC CO. RATED AT 62,500 KV.A.

weights move out, this valve is closed. Further outward motion of the governor weights simultaneously opens a bypass valve, bypassing steam from the reheating system direct to the condenser, and closes a butterfly valve in the inlet to the intermediate cylinder. A butterfly form of valve was selected in order to introduce the least interruption of flow.

Balancing of turbine rotors has received a great deal of attention. In Westinghouse practice, the rotor is speeded above the speed of resonance by means of an electric motor and magnetic clutch. The clutch is then separated and the rotor permitted to coast down in speed through resonance and the maximum amplitude observed. The clutch is then connected, the current reversed and the rotor quickly brought to rest for adjustment of balance.

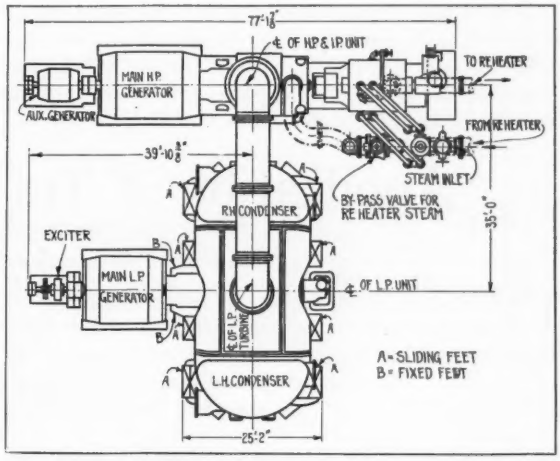


FIG. 5. PLAN OF THE WESTINGHOUSE THREE-CYLINDER TURBO-GENERATOR FOR CRAWFORD AVE. STATION

The sensitivity of this machine is such that a great degree of accuracy of balance can be secured. The balancing operating is carried out at low speed approximately 1/10 to ¼ the turbine speed, so it is necessary that the elements of the rotor be approximately in balance before being balanced in the machine in order to eliminate local couples of sufficient magnitude to cause a bending of the shaft when at speed.

Locking in of the Last Blade in Each Row

Practice differs in inserting the last blade and locking it in its slot. In the case of higher stressed blades, it was customary to omit one blade and insert a locking means in its place. In recent practice a new locking means has been devised, which permits a full complement of blades to be inserted in drum type rotors. The relative ease of blade attachment to a drum as compared with a disc is apparent.

The following shows the trend in the selection of blade materials:

Brass: Copper-zinc alloys are no longer employed for turbine blading by manufacturers of large turbines because of the general deterioration and loss of strength at elevated temperatures. They are, however, still employed for the purpose by several manufacturers of smaller turbines operating at lower temperatures.

Bronze: Copper-tin alloys containing phosphorus are likewise no longer employed for turbine blading.

Nickel steel: This is employed by the General Electric and Westinghouse Companies for impulse blading and by the Westinghouse Company for the higher stressed reaction blading.

Cupro-nickel: This alloy is used considerably by the Allis-Chalmers Co. for turbine blading and in some few instances by the Westinghouse Co.

Manganese-copper: This alloy is employed by the Westinghouse Co. for low stressed reaction blades.

Monel metal: This material has been used to some extent by the Allis-Chalmers and General Electric Com-

panies and in a few instances where copper alloys have been troublesome, by the Westinghouse Company.

Much thought is being given to the subject of higher steam pressures, and both the General Electric Company and the Westinghouse Company are building machines for 1200 lb. pressure. These will exhaust against 300 lb. back pressure. One of these will be of 3200 kw. capacity and will be of impulse-reaction type, to operate at 3600 r.p.m. A feature of the design is that the cylinder will be made of rectangular blocks of steel bored out for the rotor and blading. Another feature is the mounting of the small turbine cylinder so that it or the alinement will not be disturbed by the expansion effects of the exhaust pipe, which is also a main steam line to the low pressure units in the power house.

Manufacturers do not believe that the design of turbines for pressures up to 1500 lb. will present any insurmountable difficulties, although no practical experience has been had of the erosive action of steam at such pressures. Low steam velocities will, however, generally be employed. It is believed that total temperatures of 750 deg. F. will not be exceeded.

Application of Turbines to Small Plants

HIGH PRESSURES AND REGENERATIVE CYCLES NOW USED. COMBINATIONS OF VARIOUS TYPES POSSIBLE IN INDUSTRIAL PLANTS. BY ALFRED IDDLES*

THERE are a large number of public utility companies in the less densely populated districts of the United States using prime movers of various kinds in sizes of 100, 500 and 1000 kw. They are facing the same problems as the larger utilities; i. e., the constant demand for better service at a lower cost. This makes it desirable for them to take advantage of the improvements in the art and to utilize more efficient equipment and operating methods.

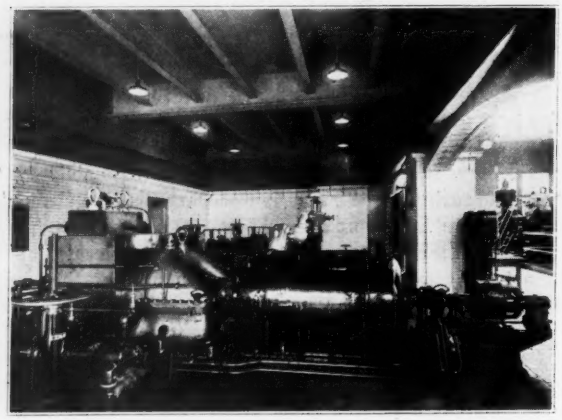


FIG. 1. SHORT ROTOR IS A FEATURE OF COMBINATION IMPULSE AND REACTION TYPE

This is a 750-kw. machine with impulse and reaction blading, and designed for 260 lb. pressure and 650 deg. F. steam. Exciter is direct connected. Oil cooler is shown in left foreground.

Similar demands for increased economy are being made upon the industrial plant and the engineer and executive in charge of such industrial plants is faced with the problem of materially reducing the cost of his power generation, or of discontinuance of his own plant and the purchase of electrical energy from the public utility, which has increased its efficiency and thereby is able to supply the industry at a lower cost.

There is also a third consideration and that is the combination of the industrial and public utility power plants. This combination can take place in various ways and is materially affected by local conditions in the particular industry. This latter phase will be discussed under a separate heading later.

In the central station field, the steam turbine is, in general, the most important and successful prime mover. There are some variations from this in special cases. The demand for increased economy in power generation and the continued use of higher and higher steam pressures has recently brought forth small steam turbines designed for pressures up to 400 lb. and a total steam temperature up to 700 deg. F. This makes available to the small central station, turbines comparable to the larger units ordinarily used, and leaves them surpassed only by the 550 and the experimental 1200 lb. turbines, which are just now going into service in the largest of the central stations.

SEVERAL TYPES OF SMALL TURBINES AVAILABLE

These small turbines are offered by the various manufacturers in the straight reaction, the straight impulse type and in combinations of these two. One manufacturer has recently developed a line of turbines utilizing one impulse stage to receive the high pressure steam and then pass it on to the straight reaction type blading throughout the remainder of its travel to the condenser. (See Fig. 1.) This combination makes it possible to construct a turbine with a much shorter rotor than would be required by the straight reaction machine and the rotor is further stiffened and simplified by making it conical in shape, with uniformly increasing area for the straight line steam flow. The governor and governor valve are located on the top of the high pressure end. The lubricating oil storage is in a tank under the high pressure end and the entire unit is quite compact and permits of a simple foundation.

Another manufacturer has recently announced a line of impulse turbines for pressures up to 400 lb. and total steam temperatures up to 700 deg. (See Fig. 2.) These machines are built in a range from 750 to 6000 kw. The design is such that an arrangement of standard parts can be made to meet the demands of a large variety of operating conditions. The turbine can be made straight condensing to utilize the best of vacuum or, by proper choice of standard parts, can be made non-condensing, or arranged for mixed pressure and extraction from one or more stages. The machine is designed so that the proper choice of the number of stages and the diameter of the wheels will permit an assembly to meet any set of steam conditions. This involves the use of, perhaps, three or four stages in some cases and as many as 14 or 15 in others. The governor mechanism is of a new type, reported by the manufacturer to have no wearing parts. It is operated by oil under pressure supplied by the lubricating

*Chief Power Engineer, Day & Zimmerman, Inc., Philadelphia, Pa.

oil pump. These machines may also be built for high back pressure operation up to 200 lb. gage. By a slight modification these same turbines can be supplied for 500 or 600 lb. pressure.

Figure 3 is an interesting comparison of the steam consumption of a turbine 8 yr. old with the common steam pressure at that time and a modern turbine using steam at 300 lb. and 700 deg. F. total temperature. The middle curve shows economy of the old type turbine with the higher pressure and temperature.

Practically all of the small turbines available for central station use can now be obtained with one or more bleeder connections, arranged for extracting steam to be used for feed water heating. The question of bleeding the main unit in a small station to supply heat to the feed water involves also the question of how the various auxiliaries in the plant should be driven. The extreme condition would be to make all of the auxiliaries motor-driven and to bleed the maximum of steam from the main unit. This scheme, however, is of doubtful value to the small station because of the liability of interruption in

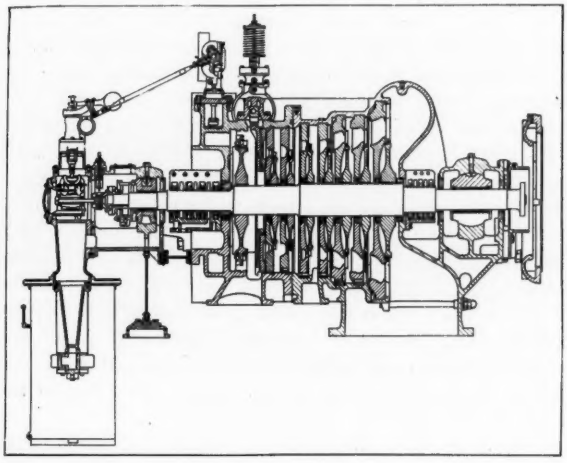


FIG. 2. PARTS ARE INTERCHANGEABLE IN THIS DESIGN

High pressure impulse type turbine built in sizes from 750 to 6000 kw. and for steam up to 400 lb. gage and 700 deg. total temperature. Standard parts can be changed to make it suitable for condensing, non-condensing, mixed pressure and extraction service.

the electrical supply to the auxiliaries and consequent interruption of service from the main plant. This is particularly true where the small station is, as usual, a unit depending entirely upon itself and in which the number of spare units, etc., is not extensive. Therefore, to assure continuity of operation and make it convenient to adjust the quantity of the steam available for feed water heating over the entire range of load, it is generally considered desirable to make certain of the auxiliary drives of the dual type.

Use of Dual Drive in Small Plants

Circulating pumps and, sometimes, the forced draft fans may be installed with a motor for the normal drive and a turbine connected on the other end of the shaft, arranged with governor control so that it automatically assumes the load in case of failure of electrical supply to the motor. This turbine drive running idle under normal conditions increases somewhat the power consumption of the auxiliaries. This increase is small, however, and is usually justified by the increased station reliability. The use of the dual drive is not new and has been found desirable even in stations where the normal feed water heating is supplied by exhaust from steam-driven auxiliaries. There is nearly always an excess of such exhaust steam at the lighter station loads and the dual drive arrangement makes it possible to obtain a better heat balance without waste of exhaust steam to the atmosphere. The boiler feed pumps are, of course, driven by steam and the balance of the auxiliaries, motor driven, except where operating con-

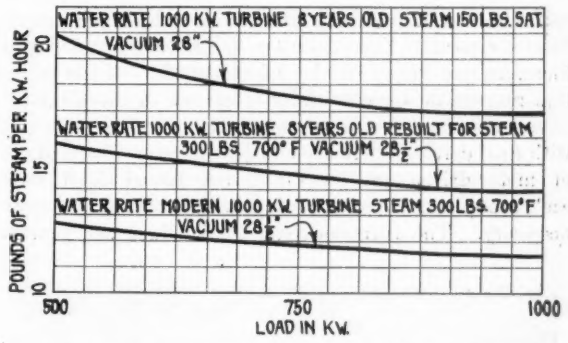

WATER RATE 1000 KW. TURBINE 8 YEARS OLD STEAM 150 LBS. SAT.
VACUUM 28"
WATER RATE 1000 KW. TURBINE 8 YEARS OLD REBUILT FOR STEAM 300 LBS. 700° F VACUUM 28½"
WATER RATE MODERN 1000 KW. TURBINE STEAM 300 LBS. 700° F VACUUM 28½"
POUNDS OF STEAM PER K.W. HOUR
20
15
10
500
750
1000
LOAD IN K.W.

FIG. 3. STEAM CONSUMPTION OF A 1000-KW. TURBINE

ditions are peculiar and the maintenance of proper heat balance over the entire range of load makes it desirable to make other combinations, such as turbine driven auxiliaries as spares and motor-driven auxiliaries for normal operation under average and full load conditions.

It is theoretically most economical to bleed the main unit at a large number of points, thus utilizing to the maximum the energy in the steam as it is expanded from the boiler pressure to condenser pressure. The increased station efficiency, however, due to the regenerative cycle brought about by bleeding the main unit for feed water heating, is less for each succeeding bleed point. For instance, if bleed steam is taken from the main unit at a point midway between atmospheric and condenser pressure, the gain in station efficiency will be much larger than the gain due to bleeding at the next higher point and this in turn greater than bleeding at the next higher pressure, etc. The practice in the large central station is to bleed at two or three points. For the small central station, if other conditions permit, it has been found best to bleed the steam from only one point.

In the past the conventional small station has used steam-driven auxiliaries entirely, discharging the exhaust from these into an open feed water heater where the condensate, returned from the surface condenser, was mixed with steam and the heated water supplied by gravity to the suction of the boiler feed pump. Such an arrangement suffers from the inefficiency and consequent high water rate of the small turbines or engines driving the auxiliaries and is liable to result in considerable loss of exhaust steam at fractional station loads because the amount of condensate available to absorb exhaust steam decreases much more rapidly than the supply of exhaust steam. This is because of the relatively poorer water rates for small engines and turbines when operating at partial loads. This arrangement has the advantage of steam-driven equipment, which is considered much more reliable by the majority of operators and has the disadvantage of a multiplicity of piping and the maintenance troubles that result from such piping. This is increas-

ingly true as the steam pressure used in the station has been increased from the conventional 150 up to 300 lb. or higher.

Use of Bleed Heating in Small Plants

As compared with this older system of feed water heating, a typical arrangement for the use of steam bled from the main unit to heat the feed water is outlined as follows: This scheme is an average of several which have been installed recently and illustrates the principle involved. Each individual plant will be different in certain details, especially those details which affect operation and, therefore, are subject to the individual ideas of the operators responsible for continuity of service in the plant.

In this case the circulating water pump is arranged with dual drive. There are an equal number (one or two) of motor-driven and turbine-driven forced draft fans, each group large enough to supply the total forced draft necessary. The turbine-driven fan or fans are kept as

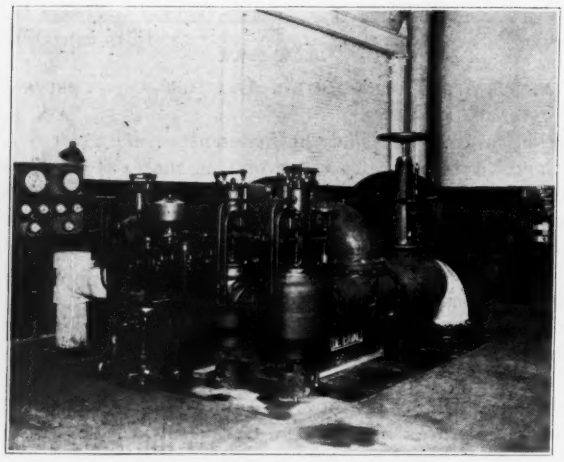


FIG. 4. BLEEDER MIXED-PRESSURE 750-KW. TURBINE WHICH OPERATES IN PARALLEL WITH TWO NON-CONDENSING MACHINES

spare units when the feed heating is normally cared for by bled steam. The control of the air to the stokers is by means of dampers on the discharge side of the fans. The boiler feed pumps are steam driven. The air from the condenser is extracted by steam jet air pumps with an inter and after-condenser through which condensate is circulated to absorb the heat in the steam used for air removal.

Stokers are engine driven for reasons of simplicity and reliability.

Arrangement is made for bleeding steam from the main turbine at one point. The condensate flows first through the inter and after-condenser on the steam jet air pumps; thence through a closed heater where the steam, bled from the main unit, heats the feed water to a temperature depending upon the pressure of the steam, which, in turn, varies with the load. The condensate then goes to a head tank where it is mixed with exhaust from the stoker engine and the boiler feed pump. The makeup water can be admitted either to the head tank or directly into the condenser hot well. This scheme will result in a feed water temperature of a maximum of 210 deg. and will be somewhat less with low loads on the main units because of the lower pressure of steam bled from the main unit.

Such an arrangement for heating the feed water by bleeding the main unit at one point will result in an increase of thermal efficiency of about 5 points. Such an arrangement has few, if any, more complications than the older type and the additional cost consists, mostly, in a closed feed water heater, a heater condensate pump and a very little additional piping. (Note: For a complete discussion of the regenerative cycle and feed water heating by bled steam in the small station, the reader is referred to the 1924 power station heat balance report of the Prime Movers Committee of the National Electric Light Association.)

Developments in the Industrial Field

Engineers and the managers of industrial plants are being forced to pay more and more attention to the production of heat and power. There are industries in which the large consumption of power in proportion to the use for heat plainly indicates the desirability of the purchase of energy from the central station supply, if such is available. On the other hand, there are numerous industries, such as textile plants, rubber plants and a large number of miscellaneous manufacturing establishments where the proper procedure is by no means so clearly evident.

We hear much these days about harnessing the water falls and the use of power generated from hydraulic developments. There are innumerable instances in which the engineer and business man might advantageously consider the proposition of harnessing the "steam fall," for the production of a portion or all of his power requirements. For instance, it is practically standard practice in the modern industrial plant to install 200 to 250-lb. boilers. Whether or not power is produced from this steam, it would be advisable to install superheaters to provide at least sufficient superheat to assure dry steam at the point of consumption.

For those plants which use steam for heat and process purposes at pressures varying from zero up to 100 or even 200 lb., it is entirely feasible and frequently advantageous to generate the steam at 200 or 300 lb.; superheat to 100 or 150 deg. and pass it through a steam turbine or uniflow engine, exhausting it at the proper pressure for use in the manufacturing plant. Such an arrangement will utilize the "steam fall" to the advantage of the industrial plant. A kilowatt hour can be generated under these conditions for an expenditure of approximately 4000 B.t.u. or somewhat less than one-third of a pound of coal. This same energy could not be produced in the most efficient central station for less than one pound of coal and in most cases for not less than one and one-half pounds.

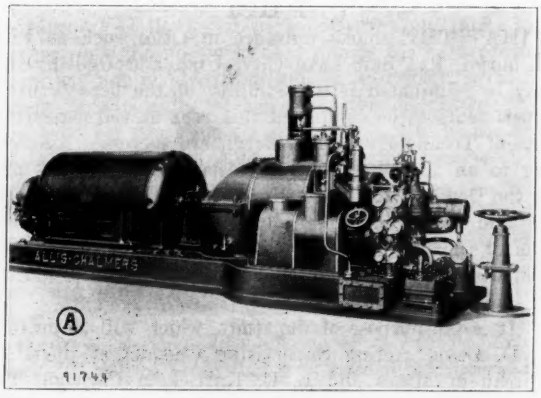
Production of this power should, of course, be charged with operating labor, repairs, maintenance and fixed charges on the investment. This, however, is usually small because the boiler plant would have to be built under any condition and the increased cost of the boiler plant for the increased pressure is exceedingly small.

There are several manufacturers who now offer standard equipment for such service. (See Fig. 5.) In the case of steam turbines the load carried on the turbine unit can be automatically regulated either by the back pressure at the exhaust or by the temperature of water or other liquid heated by this exhaust. The uniflow engine ordinarily has a better water rate than the turbine when

operating under high back pressure; however, if the water rate is of particular importance, turbines of special design can be obtained with better than ordinary water rates and their simplicity and small space requirements frequently outweigh the disadvantage of somewhat greater steam consumption per kilowatt-hour.

Depending upon the character of load to be supplied and the availability of condensing water, several arrangements can be made for the use of such turbine reducing valve installations.

In one such installation, where condensing water was easily available, three turbines of equal capacity were installed. Two were straight non-condensing turbines and one a spare for the other. The third machine was a bleeder-mixed type (See Fig. 4) supplied with a condenser and arranged so that with normal operation the bleeder machine furnished steam through the bleeder connection to an exhaust main common with either of the two non-condensing turbines, the two supplying 15 lb. steam to process in a textile finishing plant. The power



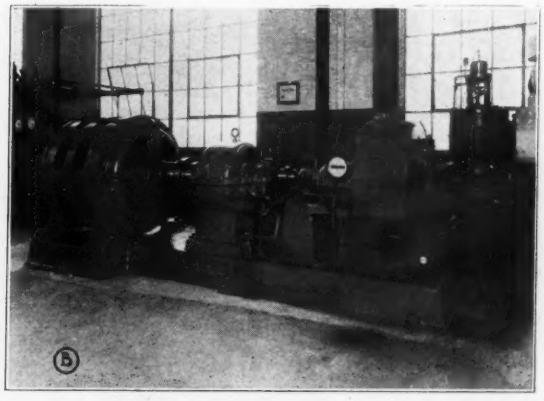


FIG. 5. TURBINE LOAD MAY BE MADE DEPENDENT ON EXHAUST STEAM REQUIREMENTS IN THESE MACHINES

A. Bleeder type turbine with automatic control of bled steam pressure. Steam can be bled at any pressure up to 20 lb. The proportion of steam through the bleeder connection is automatically controlled to maintain constant speed and the required electrical output.

B. A 750-kw. non-condensing turbine, gear connected to an induction generator. The amount of electrical load carried by the unit is automatically controlled by the pressure in the exhaust main. This controller is shown on the floor under the right hand end of the turbine.

required in excess of what could be produced by the turbines operating non-condensing is supplied by the condensing portion of the bleeder type turbine. The electrical ends of these units operate in parallel and are automatically regulated by the pressure in the exhaust main working through the governor on the bleeder turbine. The electrical and exhaust steam load curves for this plant did not coincide. They seldom do in any industrial plant. With such an installation, the power required when exhaust steam is not wanted is economically furnished by the condensing portion of the bleeder turbine. The balance of the electrical load is supplied by turbines operating as reducing valves and at a cost much less than purchased power if public utility service was available. (It was not available in this case.)

In another textile plant installation, the mill requires steam at 50 lb. pressure for process purposes. Satisfactory public utility service was not available. The load curves for power and steam requirements did not coincide particularly because the weaving section of the plant operates two shifts and a considerable portion of the total power requirements are needed during this shift when no exhaust steam is needed for process and only a small amount for heat, in the winter time. Two turbines were installed, each of sufficient capacity to carry the entire electrical load. Boilers were installed to operate at 200 lb. pressure with 100 deg. superheat.

One turbine is a straight condensing turbine served by a surface condenser. The other is a straight non-condensing turbine exhausting at 50 lb. pressure. The non-condensing turbine is automatically governed by the exhaust steam pressure with the result that this turbine carries enough electrical load to produce the quantity of 50 lb. steam required by the mill. The balance of the electrical load is carried by the condensing turbine. The load is shifted from the one unit to the other automatically by a slight change in the speed of the non-condensing turbine. This speed is controlled by a pressure actuated governor.

In case of trouble with either machine, the other machine can be operated to care for the entire electrical load, but with some temporary decrease in overall plant efficiency because of improper heat balance. The high pressure steam main is connected to the 50 lb. exhaust line through a reducing valve to supply low pressure steam in case the non-condensing unit is out of commission and to supply heat over Sunday and holidays. The boiler capacity of this plant is no greater than it would be with no turbine installed and that part of the electrical energy produced by the non-condensing turbine is produced at extremely low cost. The balance of the power is produced at a satisfactory cost considering that adequate public utility service is not available.

In another installation satisfactory public utility service was available and the power requirements were much greater than the requirements for heat. The plant is a large automobile manufacturing plant wherein the machine shop and similar manufacturing processes furnish the electrical load and the building heating and certain ovens furnish the steam load. The plant is a large one and it was thought desirable to have heating steam at from 50 to 75 lb. pressure available for distribution in relatively small pipes. These conditions indicated the desirability of at least 100-lb. boilers. It was decided to install, without much additional expense, boilers to operate at 200 lb. with 100 deg. superheat. A turbo-generator was installed to operate on steam at 200 lb., ex-

hausting at a back pressure of between 50 and 100 lb. This turbine operates in parallel on the electrical end with the public utility service and its load is automatically regulated by the pressure in the exhaust pipe. Depending upon the requirements for heat and process steam, this turbine produces varying quantities of electrical energy at an exceedingly low cost. Incidentally, it acts as a reserve to supply a certain amount of power for important processes in case of failure of the public utility supply.

In Fig. 6 is shown an installation which consists of two 300-kw. turbo-generators supplying an industrial plant in which there is considerable demand for 5 lb. gage pressure steam for heating and process purposes. The turbines are supplied with 150 lb. saturated steam. The right-hand turbine is a non-condensing unit exhausting into a 5-lb. pressure steam main. The other turbine is a condensing unit served by a condenser maintaining 28 in. of vacuum. The two machines are operated in parallel on the electrical end and the amount of load

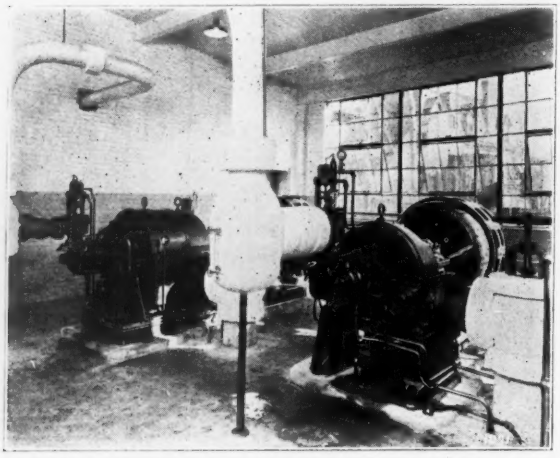


FIG. 6. AN INDUSTRIAL PLANT WITH ONE CONDENSING AND ONE NON-CONDENSING TURBINE

carried by each is determined by the requirements for exhaust steam at 5 lb. pressure. Either turbine is large enough to carry the entire load and there is, therefore, 100 per cent spare capacity so that the entire load of the plant can be carried in case one unit should be down. The operation of one machine would, of course, produce a lower plant efficiency because there would either be excess exhaust steam escaping to the atmosphere or there would be steam passing to the condenser and 5 lb. steam passing through reducing valves from the high pressure steam main.

In another installation two 500-kw. non-condensing turbines operate with 20 lb. back pressure to supply steam for process purposes. In another case which has come to the writer's attention a 500-kw. bleeder turbine is arranged to maintain 40 lb. pressure automatically in the exhaust main and to pass sufficient additional steam to the condenser to generate the total requirements for electrical energy. This turbine is supplied with 125 lb. saturated steam.

Such installations are representative of the wide range of initial and exhaust steam pressures which can be utilized successfully in an industrial power plant. It is evident from the foregoing that these turbines, acting as reducing valves to supply steam for heating and process, can be operated in parallel with each other or in parallel with a public utility supply. Such arrangement results in the maximum of thermal efficiency and if properly selected for the conditions to be met, will usually prove economical from the commercial standpoint; in other words, they pay.

Developments in the small prime mover field during the past year have been along the line of increased thermal efficiency due to improved design and higher steam pressures and a more extensive use of small prime movers in industrial plants to produce power and exhaust steam for heating and process purposes. Both developments increase the thermal efficiency with which we utilize the nation's fuel supply. If carefully applied, such schemes produce lower over-all costs, and this is the important requirement of those responsible for the commercial success of our national industry.

Carbonized Coal as Smokeless Fuel

THAT THE smoke nuisance in cities such as Pittsburgh, Pa., Salt Lake City, Utah and Ogden, Utah, may be eliminated is a possibility of the near future if experiments to be conducted this year at Carnegie Institute of Technology in Pittsburgh are successful. According to an announcement, steps have already been taken by the Department of Metallurgical and Mining Engineering and the U. S. Bureau of Mines to study the "utilization of the products of low temperature carbonization of coal with particular reference to the economic production of smokeless fuel."

It is the purpose of the study, which will be made by J. D. Davis, Acting Supervising Chemist at the U. S. Bureau of Mines and L. C. Karrick, a Carnegie Tech Research Fellow, to devise means economically feasible for abatement of the smoke nuisance in cities such as Pittsburgh, Salt Lake City, and Ogden. It has long been thought that a smokeless fuel might be prepared by low temperature carbonization of coal which would solve the problem.

That householders rather than industrial plants in such cities are "responsible" for the smoke nuisance, is an interesting statement in connection with the proposed study. "It is pretty generally recognized," says the announcement, "that the smoke condition of our cities is largely due to the domestic consumption of soft coal. This is due to the fact that soft coal is burned in domestic heating appliances with low efficiency, as it is impossible to formulate rules for combustion that will be generally observed by householders. The present research will have for its object primarily the investigation of the economic feasibility of applying low temperature carbonization in the cities mentioned."

In attacking the problem, authorities at the Institute and the Bureau of Mines intend to study the yields and qualities of the distillation products of a few typical coals in the laboratories of the Bureau of Mines at Pittsburgh, and to investigate the cost of plant, fabrication and revenue to be derived by sale of products in the vicinity of Pittsburgh, Salt Lake City and Ogden. The distillation method to be used has already been worked out on a laboratory scale and for the present, investigation will be applied on a scale large enough to yield the data required.

High Pressures Affect Boiler Accessories

HIGH PRESSURE FEED PUMPS, WATER COLUMNS FOR 1200-LB. BOILERS AND SUPERHEAT CONTROL ARE A FEW OF THE PROBLEMS WHICH HAVE HAD TO BE SOLVED

IN ADDITION to the problems involved in the design of turbines and boilers, the use of high pressures in power plants has had a marked influence on the manufacture and use of boiler accessories. Getting water into the boilers; regulating feed water levels and providing arrangements for observing the level; controlling the degree of superheat so that maximum temperatures will not be exceeded; providing safety valves which will function properly under the high pressures and temperatures; installing valves of a type which withstand the severe conditions and which will protect the boiler in all emergencies are just a few of the details which must be considered in designing a high pressure boiler installation.

SOME OF THE PUMPING PROBLEMS ENCOUNTERED

Since manufacturers of pumping equipment have had considerable experience on industrial problems requiring the pumping of liquids at high pressures and fairly high temperatures, the design of feed pumps for high pressure boilers has not involved any unusually difficult problems. Present practice calls for the generation of not over 200 ft. of head per stage and six stages appears to be the most that it is desirable to include in one casing because of the length of the shaft.

In the Trenton Channel Plant of the Detroit Edison Co., the pumps are designed to deliver 1300 gal. per min. each against 550 lb. pressure when running at 1750 r.p.m. There are three turbine-driven and three motor-driven pumps in the plant.

Figure 1 shows a view of one of the turbine-driven pumps. It will be noted that it is divided into two parts; a single stage, double suction pump taking the water from the hot well and forcing it through the various heaters to the suction of a multi-stage unit, in which the water is raised to feed line pressure. The single-stage unit is of a type especially designed for handling hot water under low suction head, being fitted with equalizing passages leading from the suction chamber to the vapor space of the condenser. The connection for this is at the top of the casing and the discharge nozzle of the pump is on the front side and the suction nozzle is on the rear side. On the high pressure unit the suction and discharge nozzles are on the same side as the discharge nozzle of the single stage pump in order to simplify piping.

In the design of high pressure pumps there are a number of points which are of interest to the user. The arrangement for taking care of mechanical thrust is important and the arrangements which are made for packing the stuffing-boxes should also be considered. It is further obvious that for high pressures, good casing castings must be obtained to stand the high pressures. Where cast iron is used, it should be hard and close grained. In some cases, the castings are annealed before machining. For the extreme range of pressures steel casings are used by some manufacturers. Split casings are an advantage in that inspection of the pump is facilitated. For the extreme range of pressures, it is probable that a split casing type of pump cannot be used and the pumps for such service may have to be built of solid ring sections. Two six-stage pumps in series appears to be about the present limitation of the split casing pump with a maximum head of 200 ft. per stage.

Care must be taken in setting up the pumps so that proper alinement is secured when the pumps are handling hot water. Provision must also be made in the pump design so that difficulties, due to unequal expansion of parts when they are heated, are avoided.

It was previously mentioned that no particular difficulties had been experienced in designing pumps for high pressure boilers. This is true for large boilers of, say, 1500 to 3000 hp. but for small installations, the problem is not so easy. In order to generate high head a pump must run at high speed and its capacity should increase directly as the speed. To obtain a high pressure in a small pump impellers with small passages are required which show a low efficiency due to the large amount of frictional surface in proportion to the amount of fluid handled.

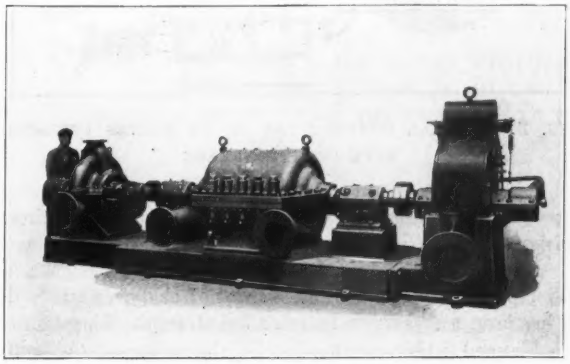


FIG. 1. TURBINE-DRIVEN FEED PUMP OF A TYPE USED IN THE TRENTON CHANNEL PLANT

Regulation of pump pressure by means of governors is a method which has been in successful operation for a number of years, but the higher pressures now in use have had their effect on these devices. In the opinion of some engineers, satisfactory results cannot be secured by controlling high pressure feed pumps by the constant pressure type of regulator. In other words, on steam pressures up to 1200 lb. the feed line pressure is so high that it is not satisfactory to operate a piston or plunger by the direct feed line pressure. For that reason the excess pressure type of regulator has made rapid progress for high pressure work. In this type of regulator the steam pressure and the feed line pressure operate on opposite sides of the piston, which in turn controls the main steam valve of the regulator. In this way the two pressures are balanced and the excess pressure in the feed line is carried by an adjustable spring, which can be set to counter-balance the excess pressure in the feed line necessary to feed the boilers properly. Figure 2 shows a typical scheme of connections for a high pressure installation.

On high pressure work pump governor bodies are being made of cast steel with special metals for the seats and discs, and with flanged connections for the piping.

With the increasing pressures and size of boilers there has been a decrease in the volume of water in the main drum per horsepower of rating. Main drums are smaller per square foot of surface than heretofore. This has resulted in the necessity for a close stabilization of the water level. Furthermore, with boilers approaching the flash type, it is apparent that the rate of feed input must more closely coincide with the rate of steam output.

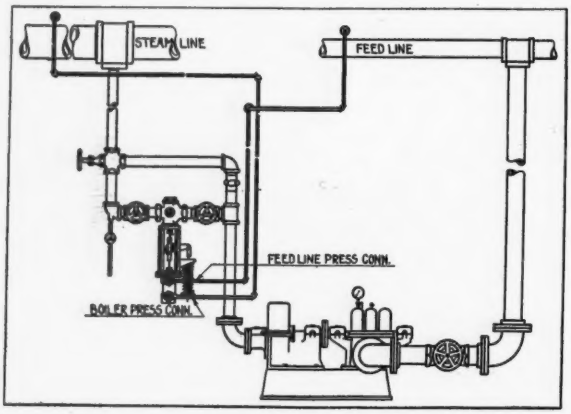


FIG. 2. TYPICAL CONNECTIONS OF AN EXCESS PRESSURE TYPE PUMP GOVERNOR

Feed water regulators have become a necessity and their design has been influenced by the new conditions.

In meeting the high pressure conditions, the general principles of regulator design have not changed, although it has been necessary to increase the strength of parts.

Flanged fittings are used on regulators in sizes as small as ¾ in., where used for extreme pressures. Stuffing-boxes in some cases have been provided with flanged glands in order to eliminate the possibility of sticking or leaking.

Difficulties Experienced in Water Column Design

One of the puzzling problems which has come up with high pressures is to provide means for observing the water level in a boiler. For steam pressures above 350 lb. the greatest difficulty in designing the water column is with the glass. Tubular water glasses can be purchased that are guaranteed up to 400 lb. but that is working close to the factor of safety and only the best glasses will give service. The average life with 350 lb. pressure seems to be about three or four weeks. The pure feed water used in high-pressure boilers affects the glass itself. With pressures above 600 lb., the use of tubular gage glasses is impracticable. It is quite difficult to pack them without breaking them, and when they break in service, as they surely will, the pieces of broken glass fly about dangerously. Flat, plain or fluted gage glasses are better for these high pressures, but the solubility of the glass and the difficulty of making the joints tight without breaking the glass in doing so render such fittings unsatisfactory. Double flat glass protected by mica on the pressure side, introduced in Great Britain, gives reasonably good results with pressures up to about 650 lb., if the glasses are fitted carefully. It is difficult to make them steam-tight above 650 lb.; the glass is broken before the gaskets can be compressed enough to insure tightness.

As the available fittings could not withstand service conditions under high pressures, one manufacturer is making a fitting which gives satisfaction, operating without objectionable characteristics under pressures as high as 1650 lb.

After the requirements for a satisfactory fitting had been determined, the design was worked out and the first gages set up for service tests about Jan. 1, 1924. In these tests the pressure has remained at or above 1600 lb. for several hours at a time, but such a test is not considered so severe as one under considerably lower but fluctuating pressures.

The fitting, as shown in Fig. 3, has a central holder, with a vertical slot connected at the top and bottom with the drum of the boiler. A cover, with a vertical slot corresponding in position to that in the holder, can be bolted to each side of the latter, these three pieces forming the body of the fitting. In making up the fitting, a gasket is

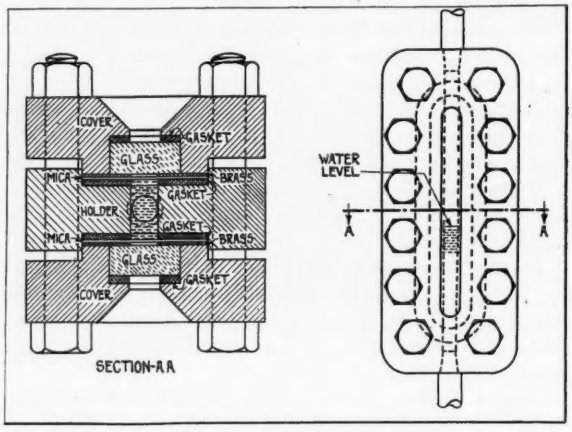


FIG. 3. DESIGN OF WATER GLASS FOR A 1200-LB. BOILER

placed in the recess in one face of the holder, then a sheet of mica cut to fit snugly, and finally a thin brass gasket. In each of the covers are placed first a gasket and then a bar of glass about 0.7 in. thick.

By this arrangement, the highest pressure that comes on the glass is the boiler pressure, for the glass is subjected to no appreciable pressure in assembling the parts. It is protected by the mica from the chemical action of the water, and the brass gasket seals the edge of the joint between the glass and the cover. It has been found that even when a glass cracks under very high pressure, which occurs rarely, the pieces remain in place and the gage stays steam-tight. Experience to date indicates that for pressures of 650 lb. and upward, the glass will have a long life, but the mica and gaskets must be renewed after a service of four to six weeks. This renewal is much easier than renewing tubular glasses for high pressures.

The angle of visibility of such a gage is obviously less than that of a tubular glass, and where any considerable difference in level must be indicated two fittings at different elevations are used as shown in the column mounting on page 1177 (Contents page).

High pressure brings up another point in column design—the questionable value of gage cocks. For pressures above 350 lb. it is almost impossible to tell whether a gage cock is blowing steam or water. Codes require the gage cocks for high pressures and it is necessary to put

them on the columns but their use as indicator is not recommended. One manufacturer of water columns states that "A gage cock on a high pressure boiler is in about the same class as spurs on an aviation officer."

Since the operator is unable to tell whether a gage cock is blowing steam or water and with the uncertainty caused by possible gage glass breakage, it is apparent that a reliable high and low level is important.

It should be kept in mind that the metal parts of a water column are not subjected to as severe conditions as fittings which are subjected to superheated steams. Steam temperatures, for instance, in four high pressure stations are as follows:

Operating Pressure	Operating Temperature	Temperature Saturated	Degrees Superheat
300	650	422	228
400	675	448	227
450	650	456	194
550	725	480	245

It is therefore apparent that 500 deg. is about the maximum temperature of operation for water columns except for such installations as may be made at 1200 lb.

For pressures above 250 lb. and where a high factor of safety is desired, columns are made of forged steel. Semi-steel, cast steel and cast iron are used for the lower range of pressures. Alarm valves are made of monel metal discs and seats in some cases and the floats are made of nickel with seamless construction.

Figure 4 shows a forged steel column and Fig. 5 is a seamless nickel float for use up to 1200 lb. and tested up to 1800 lb. hydraulic pressure. Such columns are made with either flanged or screwed water connections and water columns.

Because most high pressure boilers are of large capacity and expense of cutting them off the line is so great it is considered desirable to use not less than two columns to a boiler and to use shut-off valves in the column connections. Shut-off valves are permitted by the code with certain restrictions, which can be readily met. It is then possible to repair a water gage or any other part of a column without a shut-down.

In the discussion so far the accessories relating to the feed water have been taken up. The effect of the high pressures on the steam accessories is not the only factor —high temperatures must also be considered since 750 deg. F. final temperature is not now so uncommon.

Superheat Must Be Closely Regulated

Present tendencies in design have affected the superheating problem. This is mainly due to the fact that the factor of safety between the steam temperature called for at the superheater outlet and the maximum steam temperature that can be carried in the turbine is much smaller than formerly. Superheat must therefore be closely regulated so that maximum temperature will not be exceeded on light loads. At the same time the superheat must be maintained on heavy loads if the maximum heat utilization is to be obtained.

There are two distinct schools of superheater practice. One group advocates the convection type superheater, which is usually placed in the interdeck location or above the tube bank, and the other group favors the radiant type superheater, which is usually placed in the rear furnace wall.

Each of these types of superheaters has different characteristics. In the convection type the superheat tends to rise with rising load or when a falling off of CO_2 causes an increase of gas volume through the furnace. The radiant type acts in a reverse manner; i. e., the superheat falls off with increasing load and with a falling off in CO_2.

Many successful installations have been made of both types for it is possible by careful design to keep the variations in superheat within a minimum range. Several

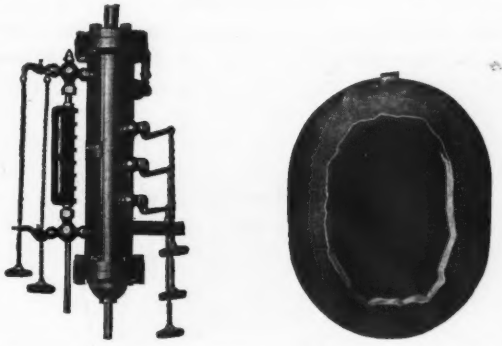


FIG. 4. FORGED-STEEL SAFETY ALARM COLUMN WITH FLAT PRISMATIC WATER GLASS

FIG. 5. SEAMLESS NICKEL FLOAT FOR PRESSURES UP TO 1200 LB.

recent installations have, however, combined the two types as shown in Fig. 6. The opposing characteristics of the two units tend to maintain a uniform superheat, regardless of load or CO_2 fluctuations.

No particular difficulties have been encountered in the building of superheaters for the extreme range of pressure as this accessory, if it may be called such, is essentially a simple and rugged device.

After passing through the superheater the steam, now at high temperature, as well as pressure, comes to the various non-return and gate valves with which the boiler is equipped. It is only necessary to observe the activity in the valve manufacturing field to realize that high pressures have placed a definite problem on the manufacturers.

By a careful study of the metallurgical problems connected with producing valves, the manufacturers have made marked progress toward producing valves which will stand the service. Monel metal fittings have played an important part in the solution of the problem. In Fig. 8 is shown a gate valve for 600 lb. pressure which is typical of the modern high pressure valve.

In the non-return valves for the Crawford Ave., Twin Branch and Philo Stations, all of which are designed for steam pressures in excess of 600 lb. Sargol flanges are used even in the bonnet joint. The valves are 10 in. double extra heavy and the port diameter is 9 in.

Difficulties encountered in obtaining sound steel castings in the smaller sizes has led to specifying forged steel valves for auxiliary throttles, drips and all small steam line stop valves. The specification of flanged valves for these purposes where screwed ends were considered satisfactory for the lower pressure, is also a development brought about by the necessity for sturdy joints to withstand the strain of the increased pressures and temperatures.

Except for the necessity of increased strength and constantly improved materials, it is not believed that blow-

off valves for the high pressures have made necessary any unusual developments in the division of the valve industry.

On the other hand, the problem of furnishing safety valves for pressures as high as 1200 lb. involves, in addition to securing the proper strength of parts, maintaining the proper valve action and capacity.

Valve Action and Capacity Important in Safety Valve Design

One manufacturing organization which has recently designed three safety valves covering a range of pressures

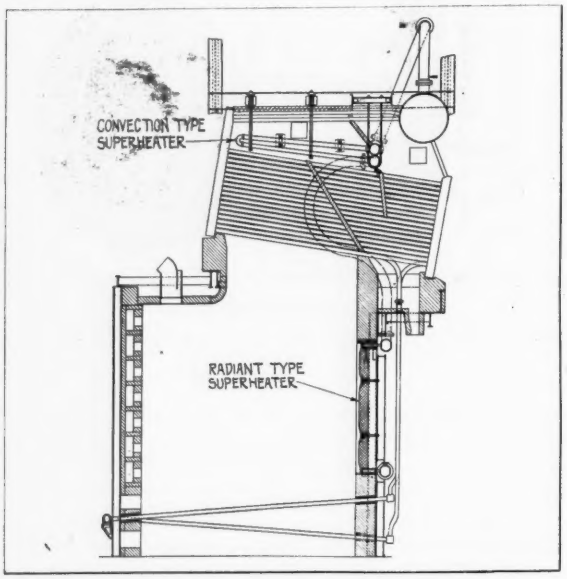


FIG. 6. COMBINATION OF RADIANT AND CONVECTION TYPE SUPERHEATER OFFERS POSSIBILITIES IN SUPERHEAT CONTROL

from 400 to 1500 lb. states that all three valves have the same external appearance. All three designs have practically the same over-all dimensions and external appearance. This seems contrary to the principle which furnishes one of the chief advantages in the use of higher pressures, that, as the pressures increase, the size of fittings, boiler tubes, etc., to handle the same power, decrease. This is true with most fittings, but there are special factors in safety valve design which offset this result for the valve taken as a whole although the seat diameter itself decreases as the pressures increase.

One principal reason for this is in the size of spring required. In any safety valve the spring must hold down the disc against a total load equal to the disc area within the seat, times the pressure carried up to the popping point of the valve. This total load is the same for a 4-in. valve set at 500 lb. as it is for a 3-in. set at 890 lb. or a 2-in. set at 2000 lb. per sq. in., so that the size of spring for these three cases corresponding approximately to the top of the range of the three valves is the same. Not only that, but the total spring load as set being the same, there is similarly the same total strain upon the valve bonnet, spindle, and other parts which therefore require the same thickness or weight of metal in the design.

Further than this, the relieving capacity of each of the three valves in pounds of steam per hour is approximately the same, the increase in capacity due to increasing pressures being offset by the reduction in seat diameters. In fact, the pressure range for each valve was selected with this in mind, to give the same capacity of 35,000 lb. of steam per hour to each valve at all pressures. Since the capacities are the same, the same size is required for the outlet or discharge piping from each valve.

Some of the design features of these valves are as follows: The spring is located entirely above the main case in all of these valves for better ventilation and cooling at the higher temperature, than is possible where the lower end is partially surrounded by the steam filled case.

The disc is guided by means of a central part or spindle below the seat, instead of with disc wings. This makes close guiding possible, without danger of binding due to expansion at the high temperatures. This construction also makes possible a larger inlet passage through the seat bushing, which is an important consideration, especially where strength for 1500 lb. pressure has to be maintained in the small 2-in. seat design. The lifting gear utilizes a toggle joint construction which reduces the hand power required at the lever, and also the side strains upon the valve in using the gear. These strains would be considerable at the valve inlet and seat if exerted at the top of such a high valve structure in operating the ordinary compound lever.

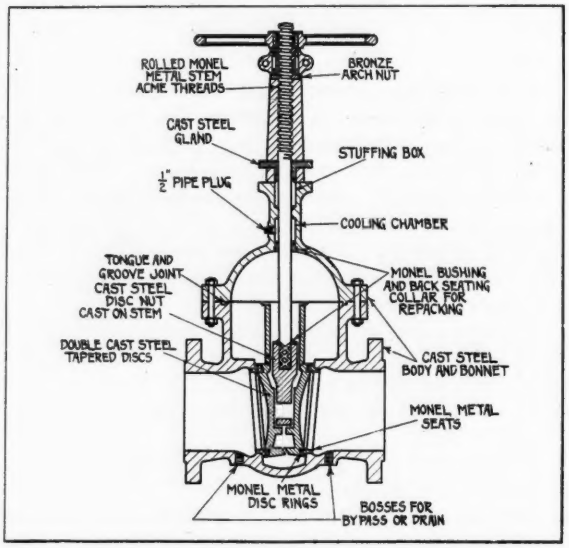

ROLLED MONEL METAL STEM ACME THREADS
BRONZE ARCH NUT
CAST STEEL GLAND
STUFFING BOX
½" PIPE PLUG
COOLING CHAMBER
TONGUE AND GROOVE JOINT CAST STEEL DISC NUT CAST ON STEM
MONEL BUSHING AND BACK SEATING COLLAR FOR REPACKING
DOUBLE CAST STEEL TAPERED DISCS
CAST STEEL BODY AND BONNET
MONEL METAL SEATS
MONEL METAL DISC RINGS
BOSSES FOR BY PASS OR DRAIN

FIG. 7. GATE VALVE FOR 600 LB. PRESSURE SHOWING USE OF MONEL METAL TRIM

The top cap is securely bolted and sealed to the top of the valve with four studs instead of by the looser fitting bayonet joint of the lower pressure designs. Small separate wedges are furnished by which it is possible to hold the spring setting when removing the top of the valve for inspection or replacement of the valve seat or disc. The body, top yoke or bonnet, levers, and spring washers are of cast steel, and the spindle is of nickel steel.

As in the case of the other accessories, trap design has also been influenced by high pressures. Cast steel or steel plate bodies are in use and, as in the case of valves, monel metal or nickel alloy parts are used where the action may be affected by high temperature steam.

One line of traps which is built as standard equipment for 600 lb. pressure is tested at from 2500 to 3000 lb.

hydrostatic pressure. This in itself indicates the limits to which the builders of traps are going to assure the production of an accessory which will meet the service con-

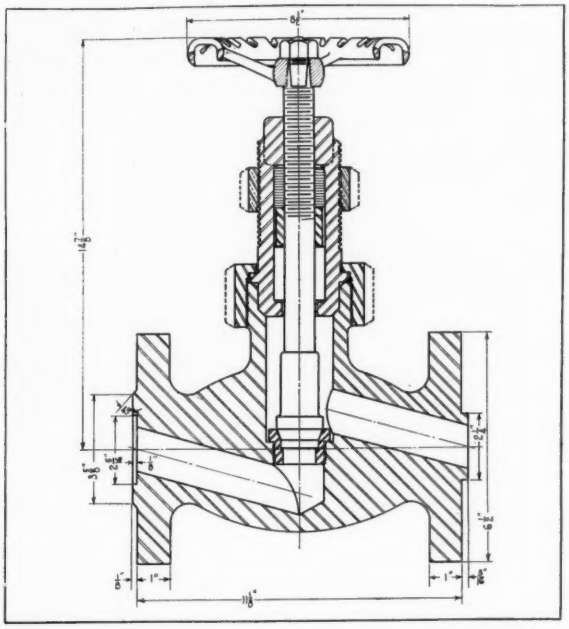


FIG. 8. FORGED STEEL OUTSIDE SCREW AND YOKE GLOBE VALVE DESIGNED FOR 600 LB. PRESSURE. DIMENSIONS ARE FOR 2 IN. SIZE

ditions in this new era of high pressure power plant design.

Cleaning Tubes in Waste-Heat Boilers

ONE difficult tube cleaning problem is that of the cleaning of waste-heat boilers in gas plants which is described by E. L. Davis in Powerfax. These boilers are similar in construction to the return-tubular type, with the water circulating on the outside of the tubes and the hot gases on the inside. The tubes are inclined upward from the front. The waste-heat boiler answers a two-fold purpose; first, the cooling of the manufactured gas as it comes from the gas machine, reducing its temperature from approximately 1400 deg., as it enters the boiler to 400 deg. as it leaves; second, the generating of enough steam during this process to operate the plant.

In the process of making the gas, a certain amount of oil is used which causes a coke deposit in the tubes of the waste-heat boilers. This deposit forms quickly, and soon reaches a thickness where it is hard to clean.

At the South Bend, Ind., plant of the Northern Indiana Gas and Electric Company are two waste-heat boilers, one containing 71 tubes and the other 108 tubes. The boilers are cleaned, on an average, every two weeks and in that time the average thickness of the coke deposit is one-quarter of an inch. At times, however, the tubes are completely clogged with the deposit. With the special tube cleaner which is used it requires two hours' time to clean the small boiler and two and one-half hours to clean the larger boiler.

This cleaner has been successful and the success of the waste-heat boiler installation is in a great part attributable to the efficient arrangement for cleaning the tubes and to the fact that the tubes can be cleaned in such a short space of time. Cleaner used is of the direct steam motor type. The motor is suspended on a specially arranged frame work which is securely fastened in front of the boiler. The ratchet arrangement allows the cradle carrying the motor to be raised and lowered or moved sideways to bring it in line with each tube in the boiler. One length of square shaft is used which is equipped with the cutting head on one end and is pushed through the tubes by two men on the handle. The shaft moves through the motor. Where the scale deposit is unusually heavy, a block and tackle with two men to pull on the rope is used in forcing the cutter head through the tube. The motor used in quite powerful and operates at a steam pressure of 110 lb. The mechanical type cutter head efficiently and thoroughly removes all of the carbon deposit.

IN ITS report on establishment of a nation-wide employment service to relieve unemployment, which has become regular rather than seasonal, the Russell Sage Foundation recommends that the federal government encourage and assist the states to maintain adequate systems of public employment offices and to coordinate these into a comprehensive system. Each state should administer and support its own offices and local governments should participate in the management of the offices in their communities by representation on the local employment committee. To coordinate the state activities, there should be a federal board consisting of the Secretaries of Labor, Commerce and Agriculture responsible directly to the President, in order to establish the non-partisan character of the service. As an additional aid to this end, a National Council and local committees should be established, consisting of representation of employers, workers and possibly other allied interests. In case of requests for workers for establishments in which a strike or lockout is in progress or pending, procedure of the Service should be such as to guarantee its neutrality.

Twenty-six states have now established such offices, hampered by inadequate funds in many cases and by inefficient methods but much progress has been made. Purely federal control is out of the question at the present time, even though it may, in the end, prove more desirable. Expediency demands, therefore, combined federal-state-local administration for the time being, at any rate.

POSSESSING extensive water power resources, Canada's progress in this field has been marked, and today there has been developed 3,227,000 hp. of the total minimum potential 18,250,000 hp. of the country's known water power possibilities. Of the developed water power, 2,411,700 hp. is in central station plants. In addition, central station systems of the country operate steam and other prime mover plants aggregating 147,109 hp. While transmission networks do not cover Canada as thoroughly as they do the more populous districts of America, there are nevertheless a number of large distribution networks in the better settled areas which make electric service available in numerous outlying districts, where individual central station service would hardly be feasible, at least for some time to come. An important percentage of the population is accordingly electrically served.

Activity in Stoker Field Shows Results

USE OF LONGER STOKERS AND WATER WALLS HAVE INCREASED BOILER OUTPUT. BETTER HEAT UTILIZATION SHOWN. BY JOSEPH G. WORKER*

IN THE business of producing power in a power station, it is possible to separate the work into three or four clearly differentiated divisions, according to the kind of combustion system used. There is the coal burning division, the heat absorbing division and the electrical energy production division. If coal is to be prepared before it is burned, this must necessarily be considered another manufacturing division. It is not difficult to believe that the time is not remote when each of these divisions is going to be on a dollar and cents business basis, that function and duty will devolve upon each, and each division will strive for the most and best and be capable of acting up to its ideas and accomplishing what it undertakes. It has been found that the completion of central stations as successful business enterprises, cannot be entirely reckoned in overall efficiencies.

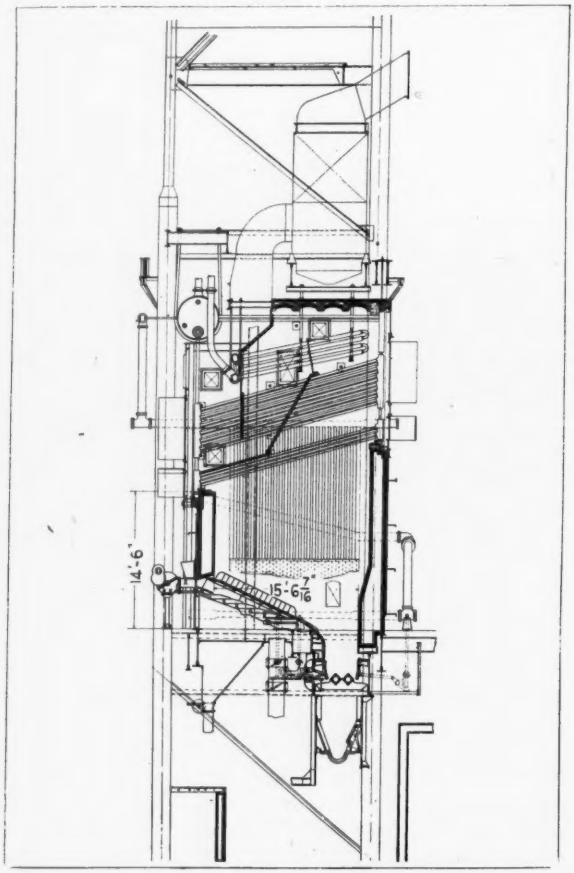


FIG. 1. MODERN APPLICATION OF THE LONG MULTIPLE RETORT UNDERFEED STOKER WITH WATER-COOLED SIDE WALLS

Mechanical stokers have to do with the coal burning division, and with this form of combustion, in connection with central station practice, there are practically only three manufacturing divisions—the coal burning, the generation of steam, and the generation of electrical energy.

*American Engineering Co.

In the past year or so, it was realized that there were still great opportunities in the development of mechanical stokers. It was found that the mechanical stoker has not reached its fullest development and even in the past year, considerable progress has been made in obtaining expert and scientific results and data that are being used in modern stoker design.

COMPARATIVE HEAT BALANCES FOR OLD AND NEW STATIONS

	Connors Creek (Detroit) Per cent	Lakeside (Milwaukee) Per cent	Hell Gate (New York) Per cent
Total heat absorbed, boilers, superheater and economizer	.....	89.1	92.7
Heat absorbed by boilers and superheater	76.0	85.3	84.6
Heat absorbed by economizer	.....	3.8	8.1
Heat carried away by dry gases	14.2	3.2	3.2
Loss due to combustible in ash or flue dust	3.6	0.5	0.4
Loss due to incomplete combustion	0.2	.....	0.1
Heat carried away by steam in products of combustion	5.0	4.9	3.4
Radiation and unaccounted for losses	1.0	2.3	0.2
Total	100.0	100.0	100.0
Flue gas temperatures leaving boiler, deg. F.	604	430	485
Per cent of rating—boiler and superheater	137	147	181
CO^2 leaving boiler, per cent	11.8	14.4	13.04
B.t.u. coal as fired	12,072	11,483	14,010
Gain in boiler eff. if flue gases reduced to 430 deg., per cent	.....	.....	1.48
Temperature air entering, deg. F	.....	104	65
Theoretical gain with air at 104 deg., per cent	.....	.....	1.00
Length of run, hr	.....	24.20	28.0
Flue gas temp. leaving economizer, deg. F	.....	204	193

One of the outstanding developments in stoker construction during the past year has been in making stokers of such sizes as will meet furnace sizes and the steaming requirements of the modern boilers. The multiple retort underfeed stoker is now made in lengths up to 16 ft. and 18 ft. (Fig. 1) and the forced draft chain grate stokers are made as wide as 24 ft. and over 18 ft. long.

With the introduction of the long 16-ft. or 17-ft. stoker as compared with the 8-ft. or 10-ft. stoker of a few years ago, has come many changes in the results that are being obtained with this method of firing.

A better utilization of the heat liberated from stoker fires has had quite a lot to do in changing the complexion of modern heat balances when compared with even those heat balances of only a few years ago.

In the accompanying table is shown the comparative heat balances for Test No. 4—Lakeside, as reported in Mechanical Engineering and tests run at the Hell Gate Plant of the United Electric Light and Power Co., New York, and an old test at Connors Creek plant of Detroit Edison Co. The Detroit Edison figures are used merely to show the advancement in stoker heat balances in the last year.

One of the outstanding changes is the reduction of the heat loss in the flue gases, which formerly amounted to 14 per cent to 30 per cent according to good or bad

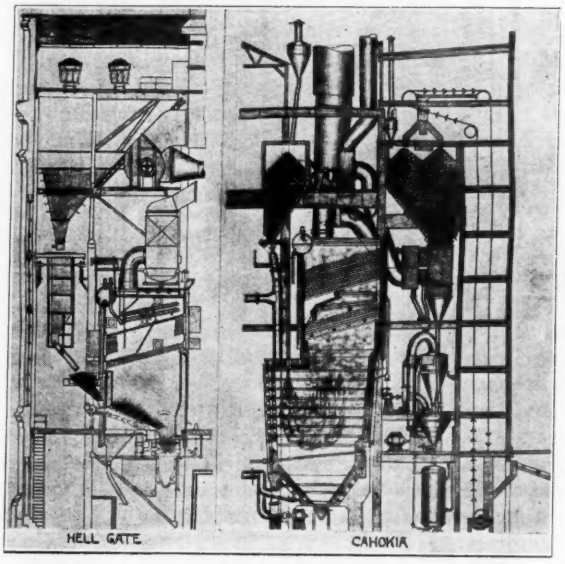


FIG. 2. SECTIONS THROUGH THE BOILER ROOMS OF THE HELL GATE AND CAHOKIA STATIONS DRAWN ON ABOUT THE SAME SCALE

practice. At Hell Gate, this loss was reduced to 3.2 per cent. This is significant and important. Even today some engineers insist upon comparing modern stoker practice and possibilities on old heat balances. The Detroit Edison engineers know full well heat process cycles and since this period of testing, have made many changes towards less heat loss. It should be noted that there is no economizer at Connors Creek and the exit gas temperature is 604 deg. F. against 430 deg. F. at Lakeside and 485 deg. F. at Hell Gate.

It will be noted by the foregoing heat balance that the longer stoker has led to a natural and logical reduction in the combustible in the refuse In the Hell Gate tests the heat loss from combustible in the ash amounted to only 0.4 per cent. A few years ago, this loss amounted to anything from 4 per cent up to 10 per cent, according to whether good or bad practice was used in the operation of the equipment.

These heat balances also show the further possibilities with respect to the use of preheated air in connection with mechanical stokers. If stokers are permitted recoveries of heated air with such refinements as are now being developed, even greater economies can be expected than those shown in the above heat balances. The Philadelphia Electric Co. are now experimenting with different types of preheaters, and work is just starting towards the obtaining of information relative to the results that can be expected on stokers when handling heated air up to 500 deg. F. and even 600 deg. F.

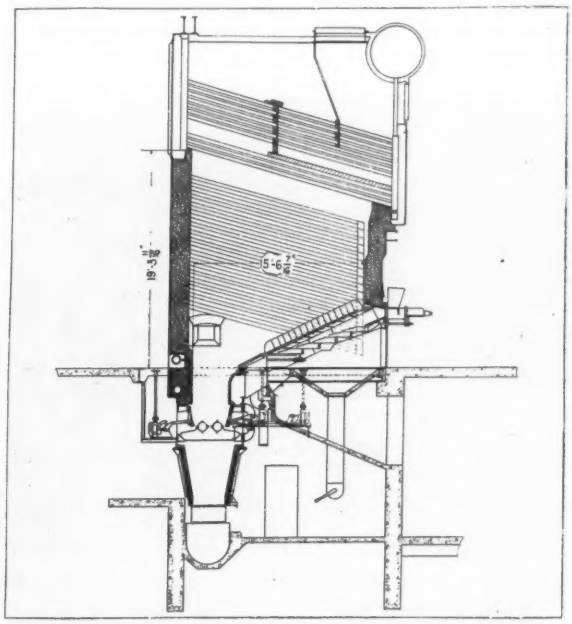


FIG. 3. APPLICATION OF HYDRAULIC TYPE UNDERFEED STOKER AT SAGINAW RIVER PLANT, SHOWING WATER-COOLED SIDE WALLS AND BRIDGE WALL

Insofar as capacity is concerned, the longer stoker is capable of burning considerably more coal per foot of boiler front, and therefore higher capacities can be obtained from not only new installations, but some of the older installations. On a recent test at Hell Gate, an evaporation of 308,275 lb. of water per hour was obtained on each boiler, superheater and economizer, using 378 sq ft. of grate surface and 8000 cu. ft. of combustion space. At the new Saginaw River plant of the Consumers Power Co., Jackson, Mich., the station is designed to obtain 600 per cent of boiler rating from 927-b.hp. boilers.

Entirely aside from the strictly economical design of modern stokers, there has been a common sentiment of stoker users demanding substantial provisions for ease in replacing and repairing stoker parts. An effort has been made not only to reduce the amount of metal that must be renewed, but to reduce the labor charge also. When one follows these minor changes through the entire stoker structure, the maintenance material and labor charge for repairing stokers has been surprisingly lowered.

Power Required for Driving Has Been Reduced

Progress has also been made in reducing the power required for stoker operation. One of the multiple retort underfeed stokers for the new Kearny station was set up

in the shop and connected to a 3-hp. alternating-current motor. When the power box clutch was in neutral position, operating the stoker mechanism, the electrical input was 1.03 hp. When the stoker was running at low speed, the electrical input was 1.19 hp., and when the stoker was operating at high speed, the electrical input was 1.33 hp. This was, of course, without any coal on the grates. It has been reported that the coal equivalent of the energy consumed by boiler auxiliary apparatus at Hell Gate, which included induced draft and the forced draft fans, was 0.08 per cent of the coal burned during the tests. At the Philadelphia Electric Co., the power required to drive a 15-retort underfeed stoker, operating at 100 per cent of rating, is about 2 hp. and when running at about 300 per cent, about 4 hp.

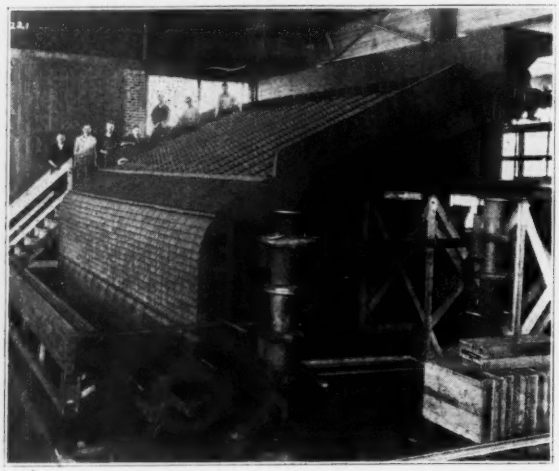


FIG. 4. UNDERFEED STOKERS FOR THE KEARNY STATION OF THE PUBLIC SERVICE PRODUCTION CO. ARE LARGEST EVER BUILT

Again it will have to be often recalled that capital invested is still of some importance. Figure 2 shows sections through Hell Gate and Cahokia boiler rooms, drawn on about the same scale—Hell Gate has economizers located above the main boiler breeching while Cahokia has not. It has been reported that the Saginaw River plant of the Consumers Power Co. with 20,000-kw. turbines and modern stoker equipment cost $71 per kw. Economy of capital without using inferior types of apparatus required close engineering study. Even at this cost, $100,000 was spent for water-cooled side and rear walls (Fig. 3). The coal handling equipment is arranged so that two men can handle from 100 to 120 T. of coal per hour from car to bunker or storage. The ash sluicing system allows one man to dispose of all the ashes in the plant.

What has been the measure of this progress in stoker development. If these accomplishments in stoker development had not been real and worth while, there would be an absence of business. A review of some of the recent large and all important stoker stations, where these advanced designs have been incorporated, is of considerable interest. One of the latest stoker stations to be contracted for is the new Richmond Station of the Philadelphia Electric Co. reported to be an ultimate station of 640,000 kw., the largest in the world. This station will start out with 12 modern long underfeed stokers under 1569-hp. boilers with economizer and preheaters. The new Kearny Station of the Public Service Production Co. is starting out with twelve 1500-hp. boilers equipped with the largest underfeed stokers ever designed (Fig. 4). The Hell Gate Station has ordered three more boilers and underfeed stokers for new extensions. The Weymouth Station of the Edison Electric Illuminating Co. of Boston is just getting under way with a modern long

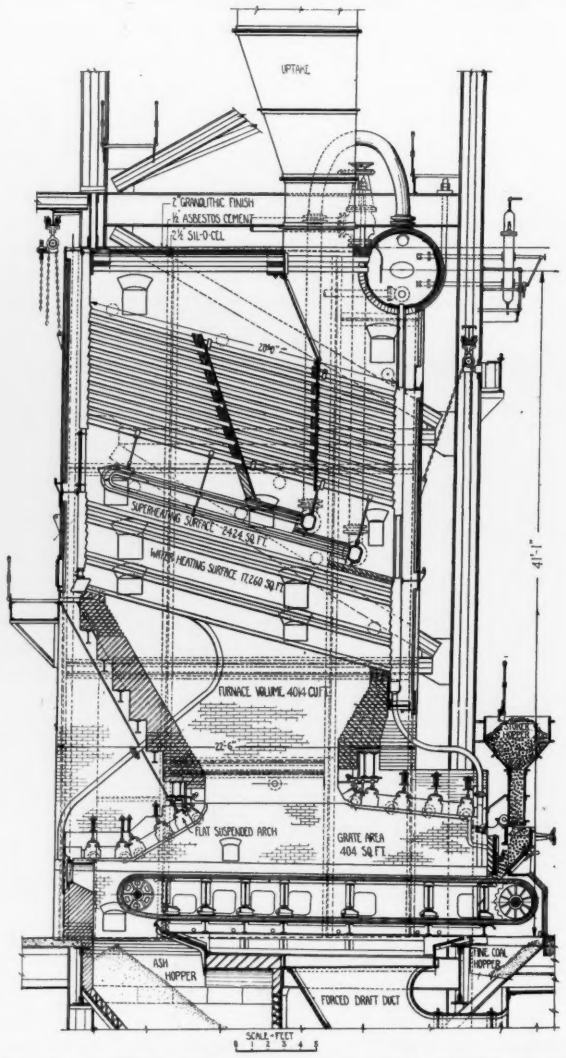


FIG. 5. MODERN INSTALLATIONS OF THE FORCED DRAFT CHAIN GRATE STOKERS FOR BURNING MIDDLE WESTERN COALS

The rear arch construction is one of the recent developments in connection with this type of stoker. Note there is a front ignition arch and an arch immediately over the rear of the stoker.

underfeed stoker equipment. The Columbus Railway Light & Power Co., Columbus, Ohio, are building the big Walnut Station with ten underfeed stoker fired, 1200-hp. boilers. The large plant, to be located near Davenport, Iowa, for the United Power & Light Co., will use hydraulic underfeed stokers with rotary ash discharge for midwest coals. The Wabash Station at Terre Haute, a superpower station, is just getting under way with forced draft chain grate stokers (Fig. 6). The extension to Calumet Station of Commonwealth Edison Co., Chicago, is started with the largest forced draft chain grate stoker ever built.

Use of Combustion Control Devices Increases

SEVERAL SYSTEMS AVAILABLE AND OPERATING RESULTS SHOW IMPROVEMENT. BASIC PRINCIPLES OF VARIOUS CONTROL SCHEMES. BY R. J. S. PIGOTT*

MANY attempts to regulate combustion in a boiler furnace, by automatic devices, have been made for more than 50 yr. With the growth of the central station, the increase in size of boilers and the advent of the mechanical stokers, the need for automatic regulation was plainly felt and a considerable number of devices were developed that purported to accomplish this end. Their total failure to live up to the claims made for them, is plainly evidenced in the general skepticism toward regulation systems, which prevails among engineers. This general attitude of disbelief has been partly due to extravagant claims for the apparatus, and partly to wrong principles of control.

But the pressing need for automatic regulation, especially in the powdered coal installations, is again forcing interest in the subject, and directing attention to the principles upon which regulation must function.

In a recent paper† for the American Society of Mechanical Engineers, the writer attempted to outline the basic principles upon which automatic regulation of any kind must be founded and the characteristics which the controlling devices must have in order to accomplish their work even when functioning upon correct principles.

EFFICIENCY AND CAPACITY IMPORTANT

There are two main things to be accomplished in any system of regulation—proportioning of air and fuel for efficiency, and proportioning fuel and air to steam demand, for capacity. The primary impulse must come from steam flow. In the older systems, steam header pressure was taken as the indication of output, and an attempt was made to hold a *constant* steam pressure. These systems were foredoomed to failure; constant header pressure, at all loads, is similar to constant speed of a turbine at all loads. While isochronous governors have been produced, of the inertia type, most of them have been subject to instability. The case of the regulator attempting to maintain exactly constant pressure is similar but worse, since the heat storage in boiler, or furnace, or both, adds to the time interval between movement of the regulator and produced result.

It follows from these considerations that a successful regulation system must work on a drooping steam pressure characteristic, the same as a turbine governor has a drooping speed-characteristic with load. Means may be provided for bringing the pressure back to a predetermined value, just as means are provided for altering the speed of a turbine at any load; but the means is always distinct from the regulating device itself, although the correcting device may be incorporated physically as part of the regulator.

Effects of time-lag must be covered by proper compensation in the regulator. For example, if a load demand drops the steam pressure, the regulator opens up in fans, dampers or stoker and increases the delivery of fuel and air to the fire; but no immediate effect on the pressure occurs, on account of the heat storage in furnace and boiler. Meanwhile the boiler increases in output up to the rate called for by the regulator, which is a *higher* rate than the actual steam demand. Unless the regulator is properly compensated, the boiler will continue at this rate until the pressure rises to the initial amount, when the regulator will close down on the fans and stoker; but the boiler, through the heat storage in the furnace, will continue to deliver steam at a greater rate than called for by the regulator, and the pressure will rise above the initial amount. This, of course, causes the regulator to cut down still further, and the process reverses. The result is that the regulator always overadjusts for changes, and therefore hunts. There are several methods of correction. The one often employed is to make the whole apparatus sluggish: but this method yields results similar to, and no better than, hand regulation. Another method is to provide compensation that will slow up or slightly reverse the movements caused by the regulator, as the initial pressure is approached. This can be done in more than one way, but is not easy to provide without some complexity.

FIG. 1. BOILER CONTROL PANEL FOR 3060-HP. PULVERIZED FUEL FIRED BOILER AT LAKE SHORE STATION, CLEVELAND ELECTRIC ILLUMINATING CO.

THREE PRINCIPLES FOR CONTROLLING RATIO OF AIR TO FUEL

Control for ratio of air to fuel may be based on several indications of proper combustion. CO_2 indication would be desirable as a basis, as all corrections, both for total quantity and variation in character of fuel, would be made in one adjustment; but as CO_2 measurement is at present unreliable for control purposes, this basis is entirely impracticable. Another method is to measure air flow and

*Mechanical Engineer, Stevens & Wood, Inc.
†Abstracted in the July 1 issue of Power Plant Engineering.

proportion fuel feed to air flow, automatically maintaining a constant ratio; change of fuel requires a manual adjustment to alter the ratio. The third method is to adjust simultaneously air flow and fuel feed to steam flow. The last two methods are practical and in successful use. The control of furnace draft has little to do with efficiency; it is only useful to avoid blowing flame out of the furnace doors and, on the other hand, to keep setting infiltration as low as possible. It should be noted that setting infiltration has not the importance for stokers and powdered coal that it had with hand fires, partly because no doors are opened to feed the fuel, and partly because settings are nowadays considerably better built against air leakage.

The characteristics a regulator must have, as a mechanical device, in order to function successfully, are four: (a) Stability, (b) Sensitiveness, speed and accuracy, (c) Reliability, (d) Power.

Elements Which Affect Stability

Stability has already been discussed; it may further be said that stability must be designed into a regulation system by observance of the same sort of factors as apply to a turbine governor. It is seldom obtainable by a single element; usually the following factors are involved:

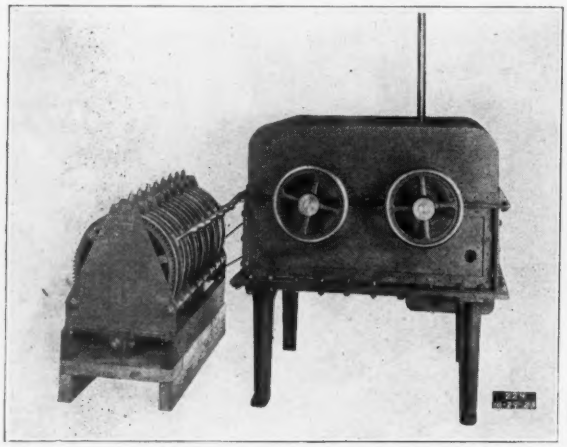


FIG. 2. CONTROL DRIVE AT CAHOKIA STATION, UNION ELECTRIC LIGHT & POWER CO.

(a) Drooping pressure characteristic of steam pressure actuation—this does *not* mean that the steam main cannot be brought back to a single initial pressure.

(b) Suitable damping, which is all the more necessary, if the regulator is made sensitive. Obviously damping should not be accomplished by making the regulator sluggish.

(c) Rate-of-change adjustment as the boiler approaches equilibrium after a change has taken place.

All of the foregoing are usually considerably involved with each other and with outside conditions. Sensitiveness, accuracy and speed usually go together but are, in commercial apparatus, often sacrificed to get an appearance of stability.

Reliability is largely a question of common sense designing: it is no use to put jewelry in the boiler room. Friction of dampers, or the resistance of valves, controllers and chain mechanisms, is largely indeterminate; therefore the regulator must be made many times more powerful than would appear to be necessary from the expected resistance. If any device to be moved sticks and the regulator is not sufficiently powerful to lug it along willy-nilly, the accuracy is, of course, impaired and compensation destroyed or the regulation goes out of service altogether.

It should be remembered, in considering the foregoing, that constant pressure at the steam header is of relatively little importance. It is only necessary to provide sufficient pressure to operate the turbines a full load; it is useful for regulation purposes, in that it may be used to indicate the steam demand. It has even been proposed by Francis Hodgkinson to operate base load stations by varying the boiler pressure in proportion to the load carried by the turbines. Inasmuch as ordinarily the partial loads are carried by throttling the present constant boiler pressure through the governor valves, it is plain that the turbine governing mechanism could be simplified to merely a speed limit and a gain in plant efficiency would result. We are not ready for this yet, nor shall we be until the boiler control is as reliable as a turbine governor and, in addition, designers and operators believe it.

It is now generally accepted, I believe, that control from static pressures, either steam, blast, or draft, is not of any value, since such static pressures do not in themselves, directly represent what we are trying to control; i. e., three rates of flow. When the static pressures are so arranged, however, as to measure flow directly, they may be properly employed for control purposes. For example, if furnace draft is kept constant and boiler passages clean, uptake draft is a function of gas flow; it is not, however, directly proportional to gas flow but substantially to the flow squared.

Classification of Commercial Systems

Principal control systems now on the market fall into two classes, those that adjust the three principal quantities in cascade, or series and those that adjust all three in parallel. For example, the Bailey control adjusts air flow and fuel to steam flow and then readjusts fuel flow to air flow; the Engineer Co. control adjusts forced draft fan speed to steam pressure, then adjusts stoker speed and uptake damper together from a balanced draft regulator over the fire. Hagan operates uptake damper, stoker drive and forced draft fan simultaneously, then adjusts blast gates under individual stokers by a furnace draft regulator, set for constant furnace draft. Carrick usually adjusts uptake damper, forced draft fan and stoker speed from steam pressure, then adjusts blast gates from furnace draft regulator. Smoot adjusts uptake damper, fuel feed and forced draft simultaneously. The Engineer Co. system is cascade or series; Bailey, Hagan, and Carrick systems are part parallel and part cascade; Smoot system is wholly parallel.

In comparing the possibilities of the various systems, an important point to examine is whether the regulator in question really meters steam output, air and fuel supply or not. For example, a number of regulating systems offer as a primary element, operated by steam pressure, a diaphragm actuated device, weight loaded and operating a hydraulic power cylinder by means of a pilot valve. The pilot valve is interconnected between the diaphragm move-

ment and the hydraulic piston movement, so that if the diaphragm shifts a certain fraction of its total movement range, the piston will bring the pilot valve back to the neutral position. This is usually termed compensation. Actually it is nothing of the sort: all these contrivances of links and levers, or chains and pulleys, or inclined bars, are nothing more than the old hydraulic position-repeating mechanism, whereby the movements of a low-powered control may have its movement repeated in proportion by means of a hydraulic cylinder for power. If the diaphragm is of rubber, it will have enough spring in it when new to give a more or less definite position corresponding to a given pressure. After about two weeks of service, the diaphragm will limber up and the spring-loading effect is removed; consequently the diaphragm is weight-loaded only and in unstable equilibrium; it can only be all the way up, or all the way down. It is easy to see that the hydraulic cylinder will simply repeat these motions and the so-called "compensation" has nothing to do with it.

A spring-loaded diaphragm, or any other device which has a *changing* load with position, will assume a definite position corresponding to each steam pressure. No direct weight loaded device, without something corresponding to springloading, can avoid instability and hunting. Obviously such a device cannot have a definite position corresponding to steam pressure or flow, therefore does not give impulses proportioned to steam demand and would prevent any secondary devices operated thereby, from functioning properly, no matter how well they may be designed. A device giving definite position from a flow meter differential, or from a drooping pressure characteristic, will be able to transmit impulses to the remainder of the apparatus, corresponding to steam flow.

Connection of the Regulator to the Control Valves

Some systems employ direct mechanical connection from the primary element to chronometer or throttle valves controlling steam to fans or stoker engines. In theory, it is conceivable that a valve mechanism could be designed that would give any increment of steam to the engine that was desired, with increments of pressure. After it is obtained, however, the question of measuring the fuel or air has still not been satisfied: the regulator has, we will assume, correctly adjusted the stoker engine throttle valve to the right position for the steam it should get; but has the stoker engine come to the right speed to give the fuel feed desired? The resistance of the rams of an underfeed stoker, for example, varies considerably and for a given throttle position and steam pressure, the speed of the stoker engine may vary 30 per cent or more. Those devices that change the loading on the stoker engine governor are, therefore, better although they are still far from perfect, on account of the relatively poor design of the engine governors.

It is fairly clear, then, that we must have real measurement of the three quantities involved: Flow differential or pressure drop for steam, flow differential by orifice, pitot tube, venturi or pressure drop across a fixed resistance (boiler differential) for air, and stoker speed for fuel. The regulator should not depend on *position* of any control device at the fans, dampers or stoker engine but should receive a check-back from the *produced result.* Incidentally, the application of the check-back from produced result in flow, will give opportunity for introducing the third factor indicated in the discussion on stability—rate-of-change adjustment of the regulators. It is relatively easy, once the check-back is furnished, to slow up the movement of the regulators as the various flows approach the proper value indicated by the impulse from the primary steam measuring device.

In several of the commercial systems, there are offered specially designed chronometer or piston valves, which can be adjusted by test, to give suitable increments of orifice area. These are without doubt ingenious but if the primary element of the regulating system functions to produce a definite flow, and does not cease to adjust until this flow is obtained, then the characteristics of the valves, rheostats or dampers are of no moment: the regulation will be independent of them. This is clearly provided in one or two systems.

Connection to Dampers or Rheostats

In most of the control systems, there is a considerable adherence to mechanical connection of the primary element to the individual throttles, dampers or rheostats. While this appears natural, in the effort to avoid complex transmissions, it must be remembered that the addition of the fairly elaborate systems of levers, shafts, pulleys and chains, adds a large possibility of friction and sticking. In the case of large plants in which the attempt is made to provide a single primary element, or master controller, for the whole plant, the mechanical connection becomes altogether impracticable. Those systems that employ normally pneumatic or electric interconnection of master and individual regulators, have therefore a distinct advantage. Moreover, the transmission by pneumatic or electric means, gives splendid opportunity for applying the compensation.

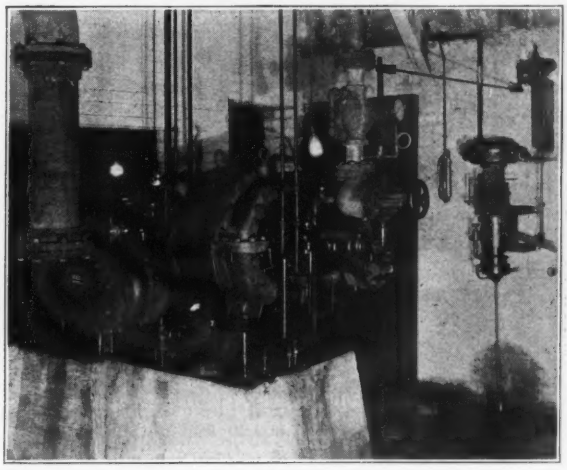


FIG. 3. FORCED DRAFT FAN REGULATOR AT LOWELLVILLE STATION, PENN-OHIO POWER & LIGHT CO.

A brief examination of the principal features of a few of the better known systems is of some use; but this will, of course, only serve as an indication of the general practicability of the system; a critical examination of the apparatus is also necessary to make a choice.

In the Engineer Company's apparatus several combi-

nations are used. The primary element is a "steam controller" which is about the same as an ordinary diaphragm actuated hydraulic damper regulator. It is direct weight-loaded but it is claimed that the master controller has definite position for definite steam pressure. If this is so the controller operates on a drooping pressure characteristic, and has one of the elements of stability. This controller operates the forced draft fan by mechanical connection (usually chain) and the capacity control is, therefore, from steam demand to air for combustion. The control for air fuel ratio is by a balanced draft regulator operating through a hydraulic cylinder mechanically connected to both uptake damper stoker engines. The stoker engine throttle is equipped with an adjustable cam for arranging the fuel feed to synchronize with the air supply. It must be adjusted by trial, to get proper air to fuel ratio.

The Bailey Meter Co.'s control system is arranged for primary control, from steam pressure, to forced and induced draft fans (or both fans and dampers) and fuel feed, all the operations being electric. Then readjustment is made of induced draft fans and uptake damper, to the correct amount by means of steam-flow air-flow relation. The forced draft fan is also readjusted to provide the requisite furnace draft. The master controller consists of a motor-driven device furnishing a periodic movement for contacting. A pressure gage alters the relations of the contactor mechanism so that the duration of the contact is proportional to the drop or rise of pressure from standard. This contact is made on one contactor for a drop below standard pressure, and on another for a rise. These contactors energize solenoid operating clutches in the "control drive" which throw suitable gears into action to shift the rheostats operating fan or feeder motors, or to move the dampers. The readjustment of the uptake damper from air-flow steam-flow is accomplished in the same general way, operating through differential gearing in the same shafts in the control drive. This system presumably operates at substantially constant header pressure, but obviates hunting by the intermittent "inching" nature of the control. If the pressure drop is rapid and large, hunting is prevented by the necessity of making several succeeding contacts, before the adjustment is completed, so that while the regulation is not sluggish in the ordinary sense, it is nevertheless fairly slow. The readjustment of fuel speed and forced draft fan is accomplished in the same general manner as that of the uptake damper but the forced fan is readjusted from furnace pressure. In cases where the rheostats for motor control do not give fine enough steps in fan speed, the control and readjustment is applied to the damper and the fan rheostat is notched up or down by limit switches on the damper control shaft, so that the damper operates largely between two points, just enough to make the fine adjustment between two adjacent fan speeds.

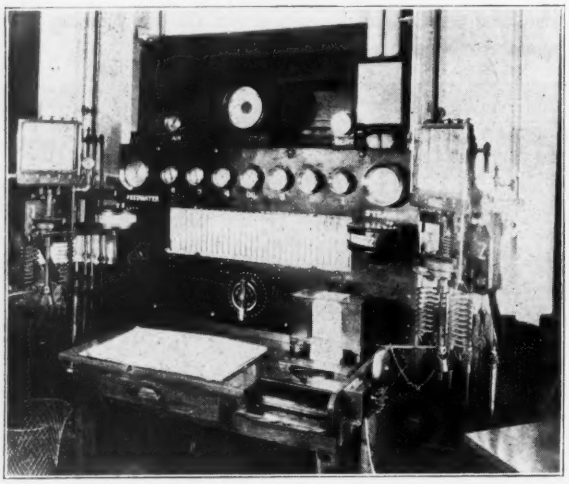


FIG. 4. CENTRAL CONTROL BOARD FOR BOILER ROOM AT LOWELLVILLE STATION

The Benjamin Engineering Co. system uses a pressure control as a master, to alter the generator field of a motor generator set, varying the voltage which is used directly on the fuel and air drives.

The Carrick system uses a mercury operated float type master on steam pressure, which operates on a drooping characteristic and has definite position for each pressure. This is usually relayed through a hydraulic cylinder, or a double hydraulic relay for heavy work where many dampers are to be operated. In another form, the relay for power is done electrically. Generally, the primary adjustment is uptake damper, stoker speed and forced draft speed, readjusting the blast gate under the stoker from a furnace draft regulator; however, as this system is offered in over 30 arrangements of control, it is difficult to give a concrete idea of the general system. The interconnection between units of this system is largely mechanical. An adjustable throttle or chronometer valve is used for the stoker engine and must be set by trial.

The Gray system, put out by the Automatic Fuel Saving Co., employs a spring loaded diaphragm as a master operated from steam pressure and works on a drooping characteristic. This master controls the air pressure in a small line, which operates the counterbalanced uptake damper by means of an air cylinder or a diaphragm and alters the stoker speed by loading the diaphragm of a spring-type regulator on the stoker engine. A furnace draft regulator then adjusts the blast gate, using air pressure for the purpose in the same manner as the master operates in the uptake damper and stoker engine regulator.

In the Hagan system a master pressure operated diaphragm regulator, which is partly weight loaded, is used. The remainder of the loading is by a second diaphragm which has a variable area in contact with the platen under it, and consequently gives a similar effect to a spring loading. This feature is combined with an air chamber and is actuated by the steam main pressure. The regulator operates on a drooping pressure characteristic and has a definite position for each pressure. The diaphragm movement is stepped up in power and amplitude by the usual hydraulic cylinder which controls the uptake damper stoker engine or motor and forced draft fan engine or motor. Where steam drive is employed, a special design of adjustable chronometer valve is used. The second adjustment is the operation of the blast gates from over-fire draft, by a furnace draft controller of the sealed bell type, powered up by a hydraulic cylinder. The connection between master regulator and individual regulators is mechanical. Adjustment of air to fuel ratio is by means of the adjustable chronometer valves, setting by trial.

As a master the Smoot system uses a spring loaded diaphragm operating an air exhaust valve and actuated by the steam pressure. This exhaust valve controls the pressure in a low-pressure compressed air chamber, to which air is admitted through a fixed orifice. The pressure in this chamber increases as the square of boiler output, the master operating in a drooping characteristic. From this air chamber is taken to each group of individual regulators, a separate line for loading them. Each of these lines is provided with a needle valve adjustment for supply of air from the air chamber, and another needle valve for bleed-off. These two valves determine the relative loading of the groups. For example, a change of one needle valve on the stoker engine loading line will alter the air-fuel ratio. Since all the pressures in all the loading lines vary as the square of boiler output, the ratio is maintained constant for all loads, for any one setting. The individual regulators are alike in design, except for the check-back loading device. They consist of a diaphragm actuated by the loading line from the master, which controls a bleed-off valve from a hydraulic differential cylinder furnishing the power. There is a dash-pot incorporated between the power cylinder and the loading diaphragm, which prevents hunting. The check-back loading for fans, either forced or induced, or dampers, is a second diaphragm, actuated by a flow device, such as an impact tube, boiler differential, or a flow meter. The loading of the check-back diaphragm stops the movement of the hydraulic cylinder, when the result indicated by the master loading line has been attained. The check-back device for speed, such as is required for stoker drive, or feeders, consists of a sensitive oil governor, substituted for the usual stoker engine governor. The regulators are applied direct to dampers or blast gates, throttle valves or rheostats, one to each. The interconnection with the master is by compressed air, and the power cylinders operate on oil or soap solution.

Opportunities for Central Control

Those systems which employ a master controller and a suitable means of transmission which does not load the regulators with heavy friction or time-lag, offers the opportunity of providing a central operating board, or control room. The advantages, and the need, of just such a control, cannot be elaborated in this article. Where it has been employed, the possibilities are already proved by records. The first station to attempt this was probably Sherman Creek (United Electric Light and Power, New York), where the Smoot system was first tried out. Hell Gate Station is now being equipped. The first central control system, combined with a complete central control room and operator, was probably the Lowellville Station of the Pennsylvania-Ohio Power & Light Co. The Bailey system was tried out at Duquesne Light (Brunot's Island) and is now installed at Cleveland Electric Illuminating Co. This system is also going into Cahokia Station, Union Electric Light & Power Co. Benjamin system is employed at Devon Station, U. G. I.

Figure 1 shows the Bailey control board for one boiler at Cleveland; Fig. 2 shows the Bailey control drive now installed at Cahokia; Fig. 3 shows a fan regulator, Smoot system, at Lowellville, and Fig. 4 shows the Central control board for 32 boilers at the same station.

Results obtained are really rather astonishing: At Sherman Creek, automatic operation has shown a gain of 10 per cent over high grade hand operation, with good stokers and settings; at Lowellville, where the previous hand operation was not so good, the gain has been 14 per cent, with short stokers and rather low settings. With pulverized fuel, the gain will not be so great, as the hand operation produces results as high as those with oil, and the margin is not so wide.

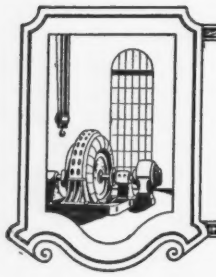
It will be noted that most of the discussion has been confined to forced draft stoker installations, simply to keep the subject within reasonable bounds. The systems described, however, are applicable to various kinds of installations. Bailey's system was developed specifically for pulverized fuel.

All the foregoing is a somewhat sketchy picture of a rather intricate and (in spite of much talk) little-understood subject. It appears, however, that we now have some real regulation available.

Causes of Carbon Deposits With Oil Firing

Deposits of hard carbon on tubes and on the furnace sides and bottom in oil firing is due to the oil striking the tubes or the brick before it has had time to burn. This is sometimes experienced even with the light grades of oil, and is caused by two defects—one, design; the other operation. The wing and bottom atomizers are sometimes placed too near the tubes and the furnace bottom. As a result the oil strikes these surfaces and is carbonized before it has time to form an intimate mixture with the air and to become completely consumed. Due to the necessity for cutting down the furnace volume in low set boilers to a minimum, this trouble is met with. Under operation, the causes are the same as those that produce excessive soot and smoke, namely, the failure to obtain an intimate mixture of the entering air and the oil at the register. It is sometimes due to too much excess air entering around the cone of oil and thereby cooling the flame down. This permits the particles of oil forming the outer surface of the oil cone to strike the furnace bottom, side walls, or tubes near the front of the furnace before they are burned. This cools them below the combustion temperature. The lighter gases vaporize and burn; the carbon remaining adheres to the surfaces as a solid mass. The same occurs when there is insufficient air for complete combustion, but this need not be considered, as the tendency is toward too much excess air. Cold oil will sometimes cause deposits.

Increase in the amount of carbon deposits when viscous oils of asphaltic base, such as Mexican and California, are burned, is due to the large proportion of unsaturated hydrocarbons contained. These are heavy and slow burning. Other things being equal, they require a longer time in which to become completely consumed. Therefore they require a longer combustion path, or some means must be resorted to that will hasten the combustion. This can be accomplished by increasing the velocity of the entering air for combustion. The area of the openings in the air-controlling registers must be closed a proportional amount so that the volume of air remains the same. It is frequently stated by engineers that "more air is needed to burn Mexican oils." This is not correct, and should be stated as follows: "A greater draft is required to burn Mexican oils, as an increase in the draft is necessary to obtain an increase in the entering velocity."



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Progress Evident in Station Electrical Design

A Summary of Developments in Electrical Design as Shown by the Large Stations Now Nearing Completion. By R. E. Argersinger*

WITHIN THE LAST two or three years a great deal of study has been given to improvements in the electrical design of large high efficiency power stations. A considerable number of such stations have either been completed or will, in the near future, be put into commercial service and it may be of interest to review briefly some of the developments which have been made and the reasons therefor.

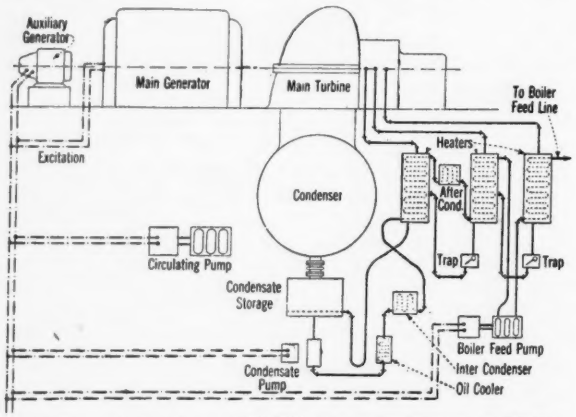


FIG. 1. DIAGRAM OF A 20,000-KW. UNIT WITH DIRECT CONNECTED AUXILIARY GENERATOR

Station Connections

No radical changes have come into use in the main power circuit connections. For stations distributing at generator voltage, the use of some form of a double bus seems to be pretty well established. Modifications may be made for ring and transfer connections but it is generally recognized that, notwithstanding the additional cost, every important station should have at least two busses from which distribution circuits may be taken. In connection with such busses the use of two selector breakers for each circuit, has in general, superseded the single breaker with selector knife switches used in some of the earlier and smaller stations. The advantage of being able to do maintenance work on one breaker or bus without interrupting service from the feeder is important, although in some cases the expense has been reduced by pairing feeders with the so-called "H" connection having one feeder connected to each bus with one oil circuit breaker but including a tie knife switch between the two feeders. On the other hand, in some of the very high capacity stations three oil circuit breakers are used for circuit, the two bus selector breakers having somewhat less rupturing capacity but being arranged so that they may be opened in case the main circuit breaker fails.

The advantages of segregating groups of generators on sections of the bus, in order to secure greater safety in operation, are appreciated and the use of bus reactors for such sectionalizing is common. Some layouts even contemplate the operation of such generator groups as separate stations, in order to avoid the tremendous concentration of energy from the entire number of generators in the ultimate station in case of short circuit. Feeder reactors to limit the amount of short circuit current flow are also widely used.

Several stations are being built for energy distribution at 66,000 v. or more and, where circumstances seem to prevent any possibility of future use for distribution at generator voltage, the low tension bus has been omitted. In such cases the step-up transformer is connected directly to the generator, usually through an oil circuit breaker, but all bus connections are made at the high voltage. There seems to be no particular objection to this arrangement except that in synchronizing with high voltage instead of with low voltage breakers the operators must allow for the somewhat slower circuit breaker action.

The use of the so-called "isolated phase" construction in recent switch house design is of great interest. The opinion seems to be very general that the separation of phases either vertically or horizontally into separate rooms is a distinct step toward greater safety in breaker operation and in the reduction of mechanical stresses between conductors under short circuits. The likelihood of phase to phase troubles is obviously decreased and the severity of phase to ground disturbances is usually limited by the use of a ground resistor in the neutral of the generators.

No changes of importance have been made in the typical layouts for group phase arrangements in this country, although in Europe considerable work has been done with the so-called "iron clad" switch gear developed in England. This equipment does away with the usual masonry construction of cells for breakers and busses and encloses all circuit breakers, instrument transformers, busses and connections in iron casings and compartments filled with compound. Whether or not this type of construction will be used to any extent in this country remains to be seen, but the attention which it has been given in Europe justifies more consideration here than has apparently been given it up to the present time.

*Electrical engineer, Stone and Webster, Inc.

The arrangement of reinforcing bars and of iron conduit in floors and walls adjacent to electrical circuits has caused some serious troubles. In case an arc forms in any compartment it may ground through these iron connections provided there is a metallic path to the steel building frame and to ground. If this path has sufficient conductivity to avoid overheating, no damage should result, but with ordinary methods of construction contacts between reinforcing rods and steel frames are poor so that local heating occurs and the concrete is sometimes badly damaged. The remedy in some cases has been to isolate the reinforcing system entirely from the building steel and also to break it up in panels. The latter practice is of especial use in isolated phase structures to prevent current flow between phases or between circuits. The reinforcing necessary in the floor systems has then been thoroughly interconnected and welded to the steel framing, thus giving a high conductivity path to ground. Such construction has been used in the Weymouth switch house.

In some other cases the electrical structures have been built of brick and soapstone slabs as in the Wabash Station of the Indiana Electric Corporation.

In the Dupont Circle substation of the Edison Electric Illuminating Company of Brockton at Brockton, Mass., concrete blocks set in cement mortar have been used successfully to obtain this same result. These blocks were made in machines at the job and the costs obtained seem to indicate that this type of construction is cheaper than either of the others previously described.

Radical changes have occurred in the layout of the station service circuits. Electrically-driven auxiliaries are becoming very generally used for two reasons—first, in order to use more economical methods of obtaining the heat balance, and, second, to increase the efficiency of the auxiliary service. House service transformers connected to the main bus are either omitted entirely or used only for relay purposes, the normal energy supply for the motor-driven units being obtained from a house turbine generator or from a direct-connected generator on the main unit shaft. Various combinations of these units are used. For example, in the Weymouth Station of the Edison Electric Illuminating Co. of Boston, a direct-connected unit on the main turbine shaft furnishes the normal energy for the auxiliaries used with that particular main unit, as well as certain boiler house equipment, but emergency connections may be made either to another direct-connected house generator or to a separate turbine-driven unit or to the main bus through transformers.

In the Hell Gate Station of the United Electric Light & Power Co. the auxiliaries are divided between a bus fed from a turbine-driven house generator and a bus supplied from transformers connected to the main bus. Normally the two service busses are not connected together.

In the Cahokia Station of the Union Electric Light & Power Co. the auxiliaries are carried on a similar pair of busses, one supplied with energy from a house turbo-generator and one from the main bus through transformers. The two busses are normally connected through saturated core reactors and the amount of load taken by either depends on the steam required from the house turbine for heat balance purposes. A number of other combinations are in use, varying with the method of obtaining heat balance in the station.

Much thought has been given to the house service bus connections, in order to secure maximum reliability for the auxiliary service and render it as independent as possible of any trouble coming in to the main bus over the commercial power circuits. The advantage of a house generator direct connected to the main unit shaft in the way of rendering the auxiliary service free from any effect of electrical trouble on the main bus is obvious. In the Long Beach Station of the Southern California Edison Co. and the Hunlock Creek power station of the Luzerne County Gas & Electric Co. such units will be used for the normal house service. Emergency service will be obtained from separate turbine-driven generators so that there will be no connection between the electrical side of the main generator units and the house service. In these particular stations this arrangement was of especial advantage as there was no reason for installing feeders or busses at generator voltage, the entire distribution leaving the stations at approximately 66,000 v.

In many of the newer stations, the truck type switchboard has been used for the control of house service generators and feeders. This equipment may be placed close to generator or motor apparatus, thus simplifying operation, shortening cable runs and at the same time, by means of the steel enclosures, affording the safety obtained in the older layouts by the use of masonry structures for housing breakers, busses and their connections.

Generators

A modern turbine-driven generator has high internal reactance and poor regulation but in the large capacity stations sudden great changes of load are unusual and ordinarily it is unnecessary to install relay types of voltage regulators, although in some recent instances the so-called "face plate" or rheostatic type of regulator has been specified.

Mica is generally used for stator coil insulation instead of the combination of mica and varnished cloth which was used in some of the earlier units. The standard temperature rise for stator windings has been set at 80 deg. C. and the mica insulation seems to show practically no deterioration at the resulting temperature. It has the further advantage of being practically impervious to corona discharges and may be used on 13,200-v. windings without showing the gradual deterioration in the form of surface pin hole punctures which, in the past, were found on many high voltage generator coils where varnished cloth insulation was used.

The recirculation method of ventilation for large generators seems to have several advantages over the earlier scheme of bringing air from out of doors into the generator and discharging it to the generator room or to the outside of the building. Some form of radiator or fin cooler for abstracting the heat from the circulating air seems preferable to the open washer although no long experience is yet available with the former type. This general scheme gives more complete control of the temperature of the cooling air than is obtained when air at atmospheric temperature is drawn into the machine. It has the further important advantage that practically all of the dirt, usually brought into the generator with the cooling air, is eliminated. This not only improves the radiation of heat from the generator coils but decreases the fire risk. There is considerable evidence to the effect that static sparking over the surface of generator windings will set fire to the oily crust which is gradually built up from the dust and oily vapor which gradually works into

the windings. This risk is materially reduced by the closed system of ventilation.

The arrangement also helps to extinguish such fires as may start because the oxygen within the closed space will be rapidly exhausted. In some instances arrangements have been made to introduce carbon-dioxide gas under pressure into the air chamber in case of fire or to allow the gas to be drawn in as the oxygen is exhausted instead of drawing in air.

Use of carbon-dioxide gas as a generator fire extinguisher has an advantage over either steam or water in that it can be introduced into the generator windings at any time without causing injury to the windings so that there is no reason for hesitation in opening the control valves as might be the case with either steam or water. It is of interest to note that in almost all recent installations of large turbo-generators provision is made for

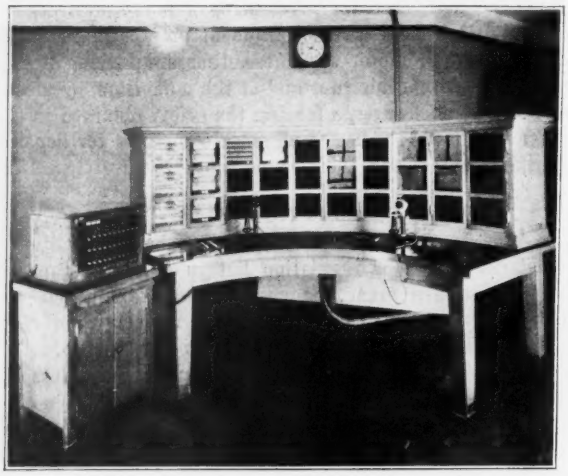


FIG. 2. MORE ATTENTION IS BEING GIVEN TO THE DEVELOPMENT OF SUPERVISORY CONTROL BOARDS. THIS IS A DISPATCHER'S DESK FOR THE DISTANT CONTROL OF 15 AUTOMATIC SUBSTATIONS

quickly applying some form of fire extinguisher to the generator windings. In the South Meadow Station of the Hartford Electric Light Co., carbon-dioxide gas is stored in a large tank under 200 lb. pressure and connections are made through permanent piping to the air chambers of the generators. The supply of gas is controlled by a diaphragm in the pipe which may be punctured manually at the discretion of the operator. The arrangement is such that this operation can easily be made automatic and operated from the generator differential relays.

Large generators are practically, without exception, installed with connections grounded either solidly or through resistance. Resistances are used in general where underground cable systems are fed directly from the generator busses in order to limit the amount of current fed into a cable disturbance. If cables are not involved, more complete protection to generator windings can be secured by omitting the resistor.

Grounding the neutral not only directly decreases the potential stresses to ground in the windings but apparently has a marked influence in reducing the static sparking which occurs over coil surfaces and, as mentioned above, has in some cases started generator fires.

Balanced relay protection has become commonly used, current transformers being located in the neutral connections as well as the line phase connections of the generator.

Circuit Breakers

The entire electrical design of the modern station hinges largely on the oil circuit breaker because of its great importance in the safe operation of the station and it is to be hoped that the future will develop some method of opening circuits in such a way as to obviate the necessity of the expensive mechanisms which now seem to be necessary to accomplish this result.

Present development of high capacity circuit breakers tends towards larger and heavier tanks and the quantities of oil used are constantly increasing so that the fire risk steadily becomes greater. Some less inflammable medium should be found to replace it or some mechanism should be developed to reduce the arcing at the time of circuit rupture. The gas exhaust muffler with piping to a main exhaust head discharging outside of the building is a comparatively new development. Tests seem to indicate that this will reduce the danger from conducting gas set free within the station when the breaker operates under short circuit conditions.

Considerable attention has been given to a type of breaker construction which permits withdrawing the circuit breaker pot with its contacts from the cell for inspection and maintenance work, thus permitting such work to be done without any possible danger of coming in contact with live circuits. Mechanisms for these large breakers are naturally heavy and rather complicated and must receive careful maintenance. For this reason the use of a separate floor on which the mechanism may be mounted offers a considerable advantage. This arrangement is a feature of practically all the stations using the isolated phase construction and may be used also in some group phase arrangements. Devices are available for interlocking the main oil circuit breaker mechanism with the isolating disconnecting switch mechanism. In some cases the disconnecting switch is operated by the circuit breaker mechanism and in others it is merely interlocked so that the disconnecting switches can be opened only when the oil circuit breaker is closed.

Transformers

The most noticeable recent change in transformer equipment lies in the increase in the size of self-cooled units. Such transformers have been constructed in capacities of 18,750 kv.a. and, if necessary, larger sizes can be built.

The increasing tendency toward line interconnections has been responsible for the construction of many outdoor switchyards and the practice of installing transformers out of doors has become general.

Difficulties experienced in the past from the formation of arcs in the tops of transformers above the oil level or the deterioration of the oil through the introduction of moisture have led to two methods of tank construction. One uses the so-called "oil conservator," a small expansion tank partially filled with oil, connected to and above the main tank which is also filled with oil. With this arrangement there is practically no danger of the formation of gases within the main tank. The amount of oil in contact with the air surface is also small and the risk of getting moisture in the oil is reduced.

The second type is used in the so-called "inert air" transformer construction. With this arrangement the tank is not filled with oil but the space above the oil surface is filled with an inert gas such as nitrogen which will not support combustion. Provision is made for expansion of the oil during changes of temperature but no outside air is permitted to enter the tank.

Recently a design has been offered which attempts to combine the advantages of the two types by leaving an air space at the top of the tank but connecting it to an expansion tank which is divided into two parts each partially filled with oil, the air space in the main tank being piped to one section of the small tank. The two compartments in the expansion tank are connected under the oil so that as the air in the transformer expands or contracts, the oil level on one side of the expansion tank changes, raising or lowering the oil level in the adjoining portion of the tank, the latter action being permitted by a breather. The small tank thus acts as an adjustable seal preventing the outside air from reaching the transformer oil.

For small transformers, particularly house service transformers, a unit is available having the leads brought directly to the tank in conduit and so designed that connections are made in a compound filled box. Such an arrangement offers some advantages where transformers are located outside of the station and it is feasible to place the delta connections inside the building. Cables may then be run directly in pipes to the transformers doing away with the more or less unsightly framework at the transformers necessary to support delta connections.

Control Boards

No particular changes have been made in the general design of control switch boards except that more attention is being given to the development of supervisory systems for controlling the operation of oil circuit breakers from the main generating station. The present designs of instruments and control equipment are such that switchboards are constantly increasing in length so that it is becoming more difficult for a single operator to perform the necessary duties. There seems to be an opportunity for the development of a type of control board having equipment much smaller in size than anything which has so far been built. Possibly some form of supervisory control equipment can be utilized for such purpose.

More attention is being paid to the use of totalizing wattmeters for indicating the total station load not only in the control room but in the turbine and boiler rooms. For this purpose the Selsyn motor control system has been used in many stations. The operating motors are of the same type used in the indicating system of the Panama lock control equipment and in the signal equipment of the Keokuk station of the Mississippi River Power Co.

Protective Equipment

The well-established use of protective reactors has already been mentioned and these units have been constructed so that if desired they may be installed out of doors.

Considerable progress has been made in the development of lightning arresters and while as yet no arrester has been proven better than the aluminum cell, other types have been developed which seem to give successful protection without the attendance necessary to the proper performance of the older units.

Apparently the short circuit or arcing ground suppressor which received considerable attention a few years ago has made little progress in favor, although such installations of this equipment as have been made seem to have yielded satisfactory results.

With the installation of large generating units built for 13,200 v., the cable problem has required thought. The phase cables are too large to be successfully built into three-phase conductors and it is desirable to avoid the use of lead sheaths as much as possible. In some instances, trouble has been experienced with corona on braided

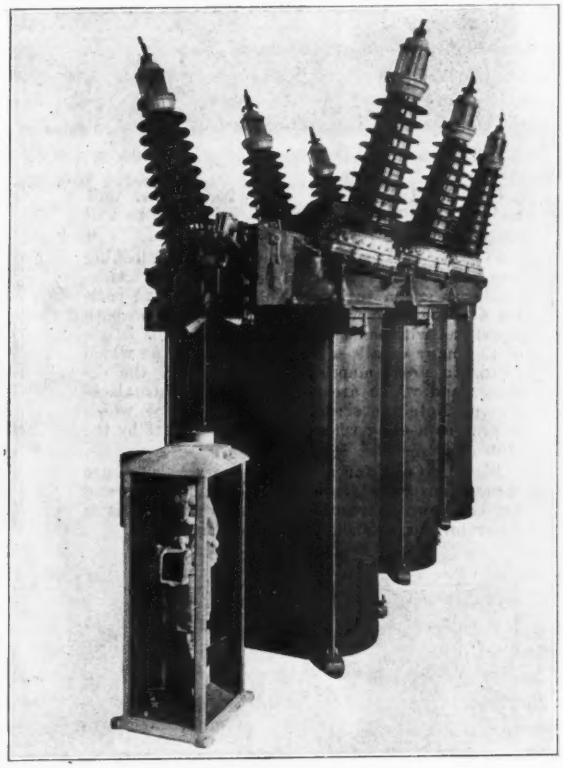
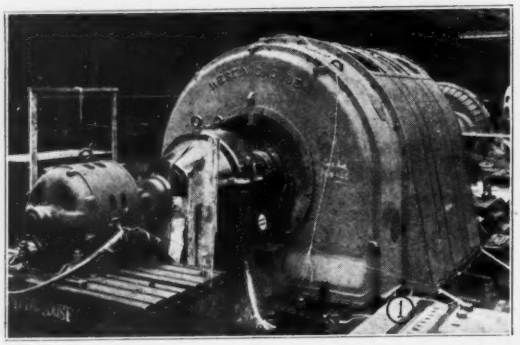


FIG. 3. A 110,000-V., 600-AMP., 3-PHASE SOLENOID OPERATED CIRCUIT BREAKER

cables where they have been placed in ducts and in a number of instances, the cables have been supported on insulators in open tunnels or corridors to the circuit breakers, as for example, in the Weymouth Station at Boston and in the Crawford Avenue Station of the Commonwealth Edison Co. at Chicago. Emphasis has also been placed on the use of high-grade insulations for station service and control circuits.

No attempt has been made in the brief outline given above to do more than point out some of the features of interest in the construction of some of the recent power stations. The electrical design of such installations seems to grow more and more complex and it is obvious, that, to be justified, they must either effect a saving in operating costs or add to the safety and reliability of such operation to a degree sufficient to render their use worth while. It is quite possible that with the growth of more substantial interconnections between stations the individual installation may be simplified due to the possibility of placing greater reliance for emergency service on neighboring stations.

Turbo Generator Construction Details



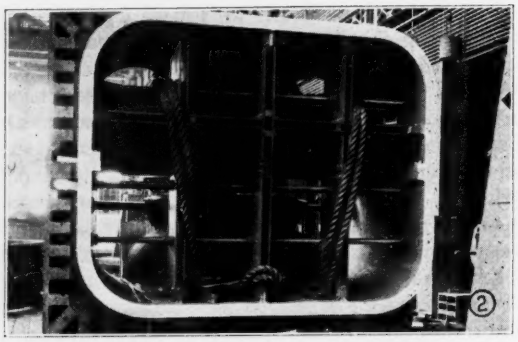
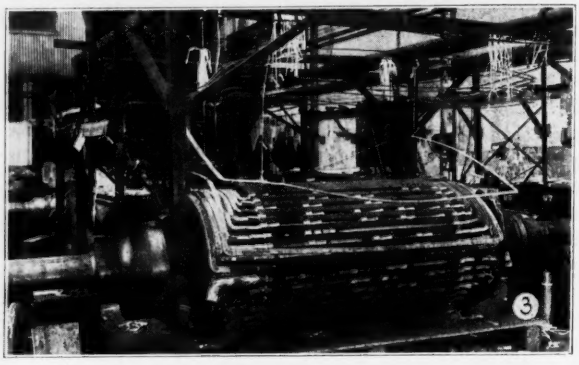


Fig. 1. Turbine end of a 25,000-kv.a. unit undergoing a test at the shop. This machine will operate at 1800 r.p.m.

Fig. 2. This is what you see when looking into the exhaust end of a 20,000-kw. Allis-Chalmers steam turbine. Note the massive casting and the manner in which it is braced in both directions with steel plates and bars. This is one of the many details of turbine construction which require a great amount of attention by the designer and which are not seen by the casual observer. Note the size of the manila rope which is used as a sling when handling this part by the crane.

Fig. 3. Coils for a large generator rotor are usually suspended from an overhead frame and are cut down as required by the winder. This is the rotor for a 25,000-kv.a. machine.



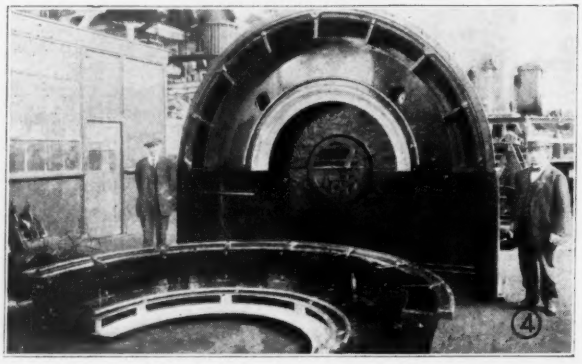
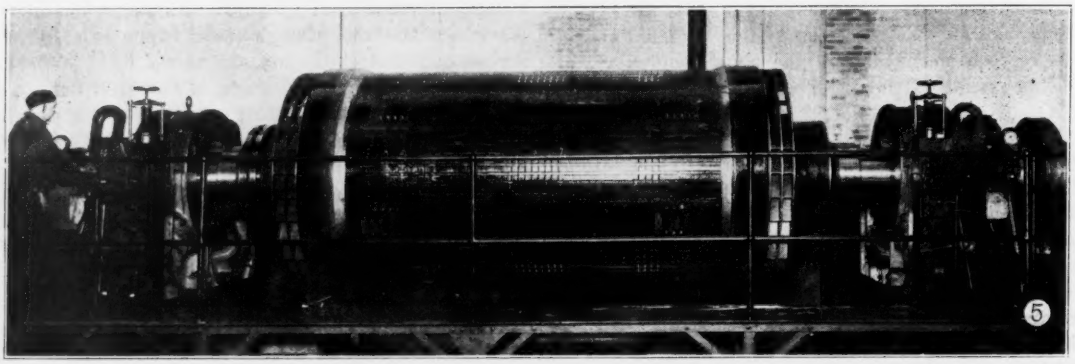


Fig. 4. This inside view of a generator end shield shows not only the massive construction but also the interesting feature of a perforated pipe, mounted on the inner surface of the shield, to be used in case of fire in the windings. This shield is for a General Electric Co. machine which is rated at 62,500 kv.a., 1200 r.p.m. and 13,800 v.

Fig. 5. Balancing of the rotative parts of large machinery is an important step in the process of manufacturing. The rotor shown here is for a Westinghouse generator which is rated at 62,500 kv.a. Balancing methods now used by the manufacturers of large machinery have been greatly simplified and the work can be accomplished with much greater accuracy than was the case a few years ago. Thus has been overcome one of the great problems of building rotative machinery.



Measuring Temperature in Electric Machinery

Modern Methods of Measuring Temperature Do Not Allow of Any Uncertainties. By I. Melville Stein*

ACCURATE KNOWLEDGE of the operating temperature of electric generators, transformers and power cables is a vital factor in the efficient operation of any electric generating plant. In the final analysis, it is the temperature to which the machine or cable rises, which limits the load. If by purely artificial means such as an air blast, we can remove the heat generated in any electrical machine at a faster rate than the machine could dispose of it without this artificial aid, we can increase the load on the machine.

Factors Affecting Heating

In Generators. While the actual load is the primary cause of the heating of the generator, the actual temperature rise is greatly affected by the load cycle, the condition of the cooling air and of the air ducts, the balance and the power factor of the load, and upon the dielectric losses in the insulation. With all these factors entering in, it is apparent that the wattmeter or ammeter indication of the load is not an accurate means for holding a machine at maximum safe output. It is the heating in the apparatus or cable that limits the safe load because it is the heating that causes deterioration in the dielectric. The heating depends on so many contributing factors other than the actual load, that a current or power measurement cannot at all times be relied upon. Obviously, the best way of knowing actual temperatures that limit the safe maximum loads, is to have those temperatures directly measured.

Transformers

Heating in transformers depends upon the same factors as does heating in generators. In addition, the continuity of the water supply in water cooled transformers is important. A further important factor in the case of transformers that are installed out of doors, is the atmospheric temperature, and, if they are exposed to the sun, the heating effect of the sun's rays must be watched.

In Cables

In high tension cables the heating depends largely upon the dielectric losses in the insulating material. The load cycle, balance and power factor of the load and the actual load, are important, because they determine the heating of the conductors as well as of the dielectric. Another factor is the grouping of cables within the conduit.

Temperature as a Basis for Load Control

Recognition, by the operating engineer, of the fact that the load capacity of electric power apparatus is limited by the temperature beyond which the insulation deteriorates, brings with it the proposition that direct measurement of temperature at the vital points of the electrical system, is the best available method for the control of the loads on the different units. The method of controlling loads by taking ammeter and wattmeter readings requires that due recognition be given the various factors that determine temperature rise in the particular unit in question, and requires application of some factor of safety to insure that danger temperatures are not exceeded. Someone has said that a factor of safety is a measure of lack of information. This definition applies well in this case. Direct temperature measurement justifies a marked reduction of the factor of safety by placing before the operator exact quantitative knowledge of the factor which limits the output of each unit, thereby enabling him to work each unit up to its safe limit.

In determining the temperature of any of various parts of electrical equipment, the electrical thermometer has been found of great value. They are read from a conveniently located switchboard meter, from wide scales legible at a distance, and when it is desired to do so, the temperatures of interest may be recorded on a chart at the switchboard and indicated at another point by a meter like a station ammeter with its scale in temperature units. Also, if desired, an alarm attachment may be mounted on the recorder to give warning when any designated upper temperature limit has been exceeded, or, when required, a simple automatic control may be installed which will act to stop the machine when the limiting temperature is reached.

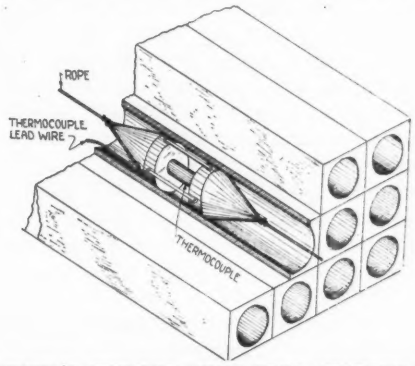


FIG. 1. SECTION THROUGH CABLE DUCT, SHOWING THERMOCOUPLE IN UNOCCUPIED DUCT

It is, of course, true that all of the factors mentioned are not important in every installation, but enough of them are usually so important in any one installation as to demand the reliable temperature indicating apparatus.

Temperature Detectors

By temperature detector we mean a device so located that its temperature will be as nearly as possible the same as that of the materials surrounding it, and which, because of temperature changes, changes its electrical characteristics in a measurable way. The characteristics upon which the measurement is based may be either changing thermo-electromotive force or changing resistance. Furthermore, the relation between electrical characteristics and temperatures must be known, so that the measurement will give accurate information about the temperature of the region in which the detector is located. Reliable measuring instruments, to complement the detectors, are, of course, essential.

The two types of electrical temperature detectors are the thermocouple and the resistance thermometer. Several

*The Leeds & Northrup Co.

units of one or the other of these two types are being installed in all the large generating units in the process of manufacture. Either type, when properly embedded, and used in conjunction with suitable instruments, is capable of giving excellent results.

The resistance temperature detector affects the reading or record of its corresponding instrument through change of resistance with temperature.

The thermocouple detector, also of proper form for the service for which it is intended, gives an electromotive force dependent on the temperature difference between its hot and cold junctions.

Generator Temperatures

Whether thermocouple or resistance-element detectors are used is almost immaterial, so far as the mechanical features of the measuring instruments are concerned. The electrical system in the thermocouple indicator or recorder is, of course, different from that employed in the corresponding resistance temperature instrument.

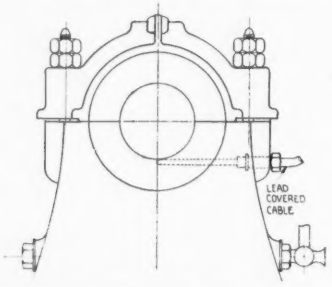


FIG. 2. A THERMOCOUPLE INSTALLED IN A GENERATOR BEARING

A recording instrument is almost always to be desired over one which merely measures but does not record, as is the case with an indicator. This is true, first, because the chart made by the recorder is of permanent value to managing officials in giving a history of what has occurred, and second, because a glance at the chart tells the operator not only present temperatures but also, what is almost as important, tells him the direction and rate of change of those temperatures. If the chart shows that the machine is heating rapidly, action is likely to be necessary some time before the limiting temperature is reached. On the other hand, if stable conditions exist, the operator is justified in holding the temperature close to the limit. Hence, to secure maximum output with minimum risk, a recording equipment is most desirable.

Furthermore, in modern power stations, the switchboard attendants have many tasks to perform, and should not be handicapped by having to take numerous observations which can be made automatically. The multiple-point type of recorder is of great value in central station practice, for it not only gives a more complete temperature record than can be obtained by having the operator read temperature indicators but the recorder entirely eliminates any effort on the part of the operator.

Cable disturbances usually arise from a combination of effects; the load on the cable itself, the heat originating from other nearby cables, heat from adjacent steam pipes, and heat from dielectric losses, all enter to affect the temperatures of a cable. It is therefore obvious that in cable installations some form of direct temperature measurement is needed. Furthermore, since some of these temperature effects vary along the length of the cable and cable duct, operating companies whose lines run through congested districts have found it necessary to make temperature surveys of their cable systems to locate the hot spots, after which cables are operated with those hot spots directly in mind.

For most temperature measurements, the thermocouple-potentiometer system is to be preferred over the resistance coil-Wheatstone bridge method. The thermocouple is more rugged and less expensive than the resistance coil detector, and when necessary can be made smaller. In permanent installations the thermocouple detector can be directly soldered to the lead cable sheath.

For cable temperature survey work a portable potentiometer indicator is recommended. Provided with automatic cold junction compensator, it is being used with complete success in this work.

Multiple-point recorders have also been used on cable survey work, and are well adapted for permanent installations. So installed, they fit in well with present practice in regard to protective relays on power cables. These relays are set for maximum protection against short circuit conditions, leaving overload protection to the care of the operator. The multiple-point recorder with high temperature alarm is a thoroughly reliable guard against overload damage. For example, a 16-point recorder with alarm attachment will automatically measure and record the vital factor in overload protection in 16 cables, and will sound an alarm whenever the temperature in any one of the 16 cables reaches a dangerous value.

Transformer Temperatures

Transformers are almost invariably installed in out-of-the-way-places, often out-of-doors, where they are subject to extreme atmosphere conditions. When they are water or oil cooled, the safety of the transformer depends upon continuous circulation. It is then evident that here, as in cables and generators, the ammeter or wattmeter indication of the load on a transformer is an indirect and inefficient method of guarding the transformer against overload. The only direct method is through the measurement of the temperature. The flexibility of the electrical methods described herein makes them ideal for transformer measurements. No matter how distant or how inaccessible, the exact temperature of each transformer may be measured and automatically recorded, or used to sound an alarm automatically. The same equipments may be utilized as are used in, measuring generator temperatures. In fact, if circumstances render it necessary, generators, bearings, cables and transformers may be connected into the same temperature indicating system.

Bearing Temperatures

Electrical methods of temperature measurement as applied to bearing temperatures are from every point of view superior to the older method utilizing mercurial thermometers located in the circulating oil. It is well known that such a thermometer is so slow in responding to changes in actual bearing temperatures that the bearing may be melted before such a thermometer will show any dangerous rise in temperature.

The increasing size of generating units, the increasing interdependence between different districts of the same net-

work, the increasing need for operation as nearly automatic as is possible, together with the increasing expense entailed by shutdowns and repairs, all combine to render a reliable and accurate temperature measuring system an important item of equipment in electric power installations.

The step bearings of large vertical shaft generating units may be entirely ruined by high temperatures due to such simple causes as a small amount of dirt in the circulating oil, or the operation of machines at a low speed for a considerable time.

In units of small size and in units where the oil circulating system is such that the temperature of the oil will give sufficiently reliable indications of actual bearing temperatures, the detector may be placed in the oil instead of in the bearing metal. In such cases, either the thermocouple or the resistance coil detector may be used, although the latter, in this case, is probably slightly more desirable.

The type of measuring equipment to be employed would vary with differing plant conditions and with the wishes of the individual operator.

Maintenance Work Should Be Systematic

By Carl Brown*

MAINTENANCE in the power plant is the result of constant vigilance and may be considered as an endless duty. Detecting the trouble in the bud, if possible, prevents many expensive situations, as a dollar today may save several tomorrow. In order to accomplish this, it is necessary that organized methods of maintenance be devised, followed out and put into force in the daily operation. By organized methods of maintenance, we refer to a regular routine of cleaning and inspections of the various units throughout the plant.

Inspections should not be confined to the machines themselves but should also include the general condition of the buildings and housekeeping in the various departments. In the power plant under discussion a general inspection of the plant takes place once a month. The chief engineer goes through each department with its foreman and during such inspection notes are made of any conditions that are unsatisfactory, such as steam and water leaks, defective valves, wasteful use of material, and rubbish or waste found tucked away in corners.

Record of the inspection is kept in the office, and each of the various foremen is required to report when each item has been corrected in his department. Such inspections not only help eliminate fire hazards but they also tend to make the men more careful to clean up their material and take care of their tools after they have completed a job. The proof of cleanliness is in the basement and not on the operating floor which is under constant observation.

Repair work, in general, throughout the boiler room is materially helped by the use of a boiler room log as shown in the accompanying illustration. It is a daily report written up by the water tenders and the foreman of the repair gang, concerning their respective shifts. On the back of the report space is provided for special remarks. The water tenders report which boilers are on the line and banked, when blowdowns are made and when soot blowers are used. Fires cleaned at night and reports on the water softener are also made by the water tenders. They also make note of repairs which they consider should be made when the boilers are down for repairs. These reports include such items as uneven feed gates, leaky valves, sticking soot blowers, water regulators out of order, etc. By this means much of the repair work on a particular boiler is known in advance and the anticipated material can be provided.

The foreman's log contains a report of all repairs made during the day, the material used and on which boilers. This report is the basis of making up a stock of furnace and boiler room supplies, and permits carrying an adequate stock at all times.

Boiler Cleaning Routine

A regular routine of cleaning and inspecting boilers is maintained and record of the number of hours each boiler has been on the line since last cleaned is kept in the office. Boilers are kept on the line a specified time before they

*Sioux City Gas & Electric Co.

Feb 8, 1924

SIOUX CITY GAS & ELECTRIC CO.

WATER STREET STATION

BOILER ROOM REPORT

Turb. = The water from the Jet Condenser

L.D. Pump = Well Water

TIME	BOILER NUMBER 1	2	3	4	5	6	7	8	9	10	11	12	Feedwater Temp.	WATER USED FOR BOILER FEED L.D.Pump	City	Eng.	Turb.
A.M. 7:00	X	X	0	X	X	0	0	X	X	X	X	0	198				✓
8:00	X	X	0	X	X	0	0	X	X	X	X	0	199				✓
9:00	X	X	0	X	X	0	0	X	X	X	X	0					✓
	X	X	0	X			0	X	X	X	X		197	✓			
2:00	X	X	0	X	X	0	0			0	—	—	196	✓			
3:00	X	X	0	X	X	0	0	—	—	0	—	—	197	✓			
4:00	X	X	0	X	X	0	0	—	—	0	—	—	198	✓			
5:00	X	X	0	X	X	0	0	X	—	0	—	—	199	✓			
6:00	X	X	0	X	X	0	0	X	X	0	X	—	200				✓

Boilers Cold 0

Boilers Banked Fires ..... —

Boilers in Service X

Fireman First Shift

Fireman Second Shift

Fireman Third Shift

Chief Engineer

BOILER ROOM LOGS ARE AN AID IN DETERMINING NECESSITY FOR REPAIRS

are taken off for cleaning, unless there is sufficient cause for taking them down, such as leaking or ruptured tubes. Records are kept of all boilers, when they are put on the line and taken off, so that each one is cleaned in its turn.

After a boiler has been killed and has cooled sufficiently to allow admittance, an internal examination is made by the foreman of the repair gang. In this examination he notes the condition of the sidewalls, arch, bridgewall, tubes, baffling, superheaters, soot blowers, etc., and makes a report as to what repairs are necessary, together with those reported by the water tenders on that boiler, before it can be put in service again. In case extensive repairs are necessary the chief engineer is notified and his consent is necessary after his personal inspection, before the work is begun. It may be found that the repairs are not as extensive as at first thought, or that part of the work is unnecessary.

After a boiler has been cleaned, it is reported ready for inspection and is inspected by the chief engineer or his assistant. This inspection checks up the repair work, tubes, baffles and also tools that may have been left inside the boiler. After being inspected the cleaning doors are sealed, coal is run in, and the number of the boiler is chalked on the blackboard as ready for service.

Boiler room auxiliaries are examined and tested periodically. Stoker engines are inspected daily. The boiler feed pump is under constant observation, and is taken down every two months for a general overhauling. This period may vary a little depending on the condition of the feedwater. Particular attention is given to the thrust bearing, steam strainer, condition of the blading and the governor. Before going on duty the machine is overspeeded to check the tripping device.

All steam traps are inspected and tested daily.

Boiler automatic valves are inspected weekly, and are oiled and tested to see if they are working freely. A report of this inspection is included in the boiler-room log.

Units and auxiliaries in the engine room are inspected and tested once a week. Overspeed safety devices are tested once a week. Overspeed safety devices are tested on each turbine, by operating the governor manually, the vacuum and speed being noted when the machine shuts itself down. Field brushes on the generator and the turbine governor are also inspected to determine if they are in good operating condition. Results of this inspection are sent to the engineer of the company.

All inspections are under the direction of the chief engineer and many of them are made by him personally.

Oil Burners for Small Plants

By W. F. Schaphorst

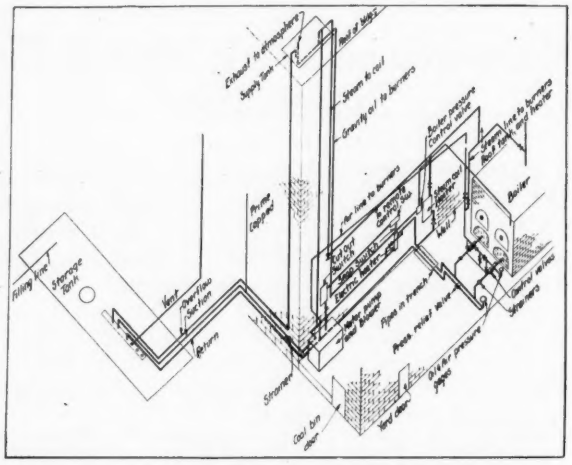
FREQUENTLY the writer has been asked regarding the feasibility of oil burners in small plants, particularly in connection with horizontal return tubular boilers. Little information on small installations has been available up to the present time because engineers have given most of their attention to the large plants where the first cost of installing new oil burning equipment can be more readily borne.

To assist those who wish to know how to install oil burners in small plants a sketch is submitted herewith which shows the arrangement in detail of an actual comparatively small installation. The sketch shows the principal pipe connections and the arrangement of piping all the way from the storage tank, which is placed beneath the ground level at the left, and the boiler at the right.

This particular boiler is a 50-hp. horizontal return-tubular boiler operating at only 75 to 80 lb. gage pressure. Gravity and pressure feed systems are shown, both being controlled by boiler pressure. This arrangement of burners, piping, etc., can be readily adapted to 5 to 100-hp. units.

Before the oil burning system was installed this plant burned from 90 to 100 T. of soft coal per season. The storage tank is made of ¼-in. steel, is 38 ft. long by 7 ft. 3 in. in diameter, and has a capacity of 10,000 gal. The overflow piping is 1 in. in diameter, the suction pipe 1 in., and the return pipe ¾ in. A ½ hp. motor drives the pump, pumping 70 gal. per minute while the blower is capable of handling 18 cu. ft. of air per minute.

Pipes in the trench are ½ in. in diameter and the pipes leading from the trench pipe to the burners are ⅜ in. in diameter. The supply tank on the roof of the building has a capacity of 200 gal. The steam pipes and gravity oil pipes running up to the tank are ½ in. in diameter.



OIL PIPING SYSTEM FOR SMALL BOILER PLANT

At the time of writing, gravity feed and steam atomization are not used, but in the near future it is planned to add them to the system as shown in the sketch. This will permit shutting off the motor for possibly 7 hr. per day.

Gravity system requires the motor to be in operation for only about an hour in the morning until the boiler pressure is about 25 lb., at which time it can be switched over to steam atomization and the gravity system. In the summer months this pressure can be obtained in 20 to 50 min. The use of the gravity system will mean an important saving.

To be sure, in small installations the saving cannot be so pronounced as it is in the larger installations; nevertheless it is gratifying to note that oil burning systems are being adapted to smaller units and that they can there be economically and advantageously used. The working pressures used in the above described plant are: for the atomizing agent, 7 to 8 lb. per sq in.; and the oil pressure varies from 10 to 20 lb. per sq. in. according to the load.

Foundations for Machinery Are Important

RIGIDITY IN THE SUPPORT OF POWER PLANT EQUIPMENT IS ABSOLUTELY ESSENTIAL IF THE UNITS ARE TO BE KEPT IN PROPER ALINEMENT

MACHINERY, regardless of the class of workmanship which has been put on it in the shop, will not operate satisfactorily unless the foundation is adequate and the work of erection has been done with great care. One can neither afford to pass over lightly nor neglect any one of the numerous steps which must be taken from the time the foundation is first planned up to the time that the machinery is put into final operation under load.

Proper construction and proportioning of the foundation is essential to the continued good running, noiseless operation and absence of vibration of any piece of machinery. It is therefore important to set the foundation in good soil and in accordance with the foundation plan furnished with each unit. A foundation plan is usually made up specially for each job by the manufacturer's engineering department and mailed to the customer either direct or through their authorized representative immediately after receipt of full information, such as, the hand of the engine, the direction of rotation, generator prints, sizes and details of belt or rope wheels and location of the steam inlet and exhaust connection.

The foundation shown on each drawing furnished by the manufacturer is the minimum size that should be used with good soil conditions. In case of poor soil conditions such as quicksand, swamps, saturated earth, etc., the purchaser should apply to the engineering department of the manufacturer for revise foundation drawings or at least take this up for recommendations as to the most suitable construction.

Where the new foundation embraces old concrete or other masonry foundations or where the unit is placed on existing foundations, wedge bolts can be furnished for which the existing masonry must be drilled with holes of a specified size and depth. These bolts then are grouted in, preferably with sulphur.

Foundations should be made of a good grade of concrete and the proper proportioning should be assured by having it done by someone experienced in this work and familiar with local conditions. The foundation should be separated from foundations of building walls or columns by a space of not less than 6 in. which space may be filled in with sand, cork, or pitch to prevent transmission of vibration to the buildings.

SPACE MUST BE LEFT FOR GROUTING

Foundation plans show the allowance to be left for grouting and the bolt projection should be checked up to assure at least a full nut fit on each bolt. Foundation bolts and anchor plates are generally furnished by the manufacturer and are shipped at the time the plans are mailed.

To assure the proper bolt spacing a wood template should be made similar to that shown in Fig. 1. It should be made amply rigid to withstand distortion. Location of the template should be carefully checked for proper alinement with the center line of the unit or the center line of shaft to which the unit may be belted or coupled.

Foundation bolts should be set in 3-in. pipes or 3 by 3-in. boxes so that they will not be rigid and so that they can be moved slightly to accommodate the cored bolt holes in the unit base or sub-base. Slight variations are unavoidable. These pipes should be set about ½ in. below the top of concrete so that the base will in no case rest on the pipe. If boxes are used they should be removed when the concrete has set. All concrete should be allowed to set for at least 3 da. before attempting to place the unit.

While the foundations for turbine-driven apparatus do not need to be as large and massive as do the foundations for reciprocating engine-driven machinery, nevertheless the success and permanency of the installation depends to a large degree upon the design of the foundations. The type of foundation construction used will vary widely with the size and specific requirements of the unit under consideration and with local conditions of soil and power house design. Every turbine foundation must be sufficiently strong and rigid to support the unit permanently and keep it in alinement. It also must be of sufficient size and mass to prevent "sounding board" vibration. Concrete is the material which best complies with these requirements because of the ease with which it may be made and used in all types of construction and on account of its wide distribution.

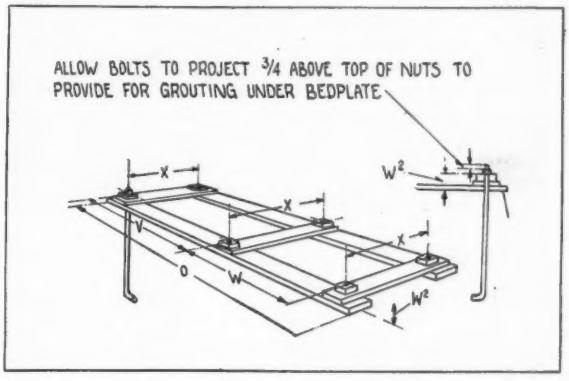


FIG. 1. WOODEN TEMPLATES ARE ESSENTIAL FOR PROPER SPACING OF FOUNDATION BOLTS

SPECIAL FOOTING IS SOMETIMES NECESSARY

For most units the mass or solid block type of construction is usually to be recommended. In the plan view such a foundation would of course be a few inches larger each way than the outline of the baseplate of the unit. In general, from the standpoint of strength and rigidity, the depth of a foundation of this character should be at least as much as the average width of the unit. It should extend into the ground enough farther than the depth just named in order to obtain a firm footing upon rock, packed gravel, sand or firm subsoil. Should it be impossible to secure a rock footing it is advisable to set the foundation proper upon a concrete footing several feet larger each way in plain view than the foundation proper and from 18 in. to 3 ft. thick. In soft and insecure earth it may prove necessary to set the footing upon wooden piling in order to hold the foundation in position.

Sometimes it is desired to set a unit directly upon an existing concrete floor, upon steel building frame work, or even upon a wooden floor. This may be done in the case of small and compact units only and for such installations it is usually best to pour a concrete slab foundation for the unit directly upon the supporting floor. The thickness of this slab should be from one-third to one-half the width of the unit. The slab should be reinforced with steel rods embedded in the concrete one and 1½ or 2 in. from the surface on both the top and bottom.

On the larger foundations even of the mass construction it is necessary in many cases to provide passages through the foundation for the admission and discharge of air to and from the generator or for the exhaust piping. When the condenser is set directly beneath the turbine, the foundation construction at this end at least becomes of the "hollow" type with large arched openings to the sides and end for the reception of the condenser. The supporting columns of such a foundation must be carefully reinforced with steel rods and I-beam reinforcement of liberal proportions must be carried over the tops of the longitudinal arches. This longitudinal I-beam reinforcement should also be tied together with I-beams embedded in the concrete crosswise of the foundation.

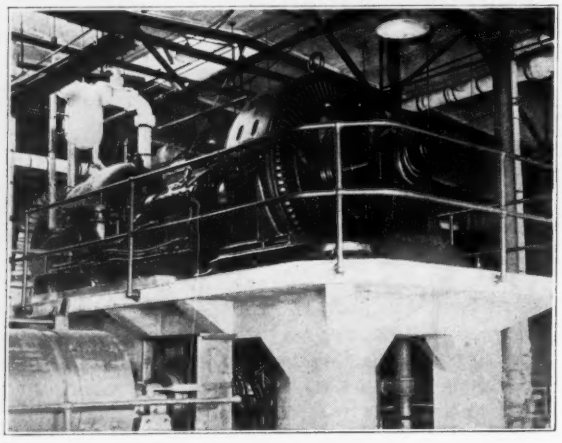


FIG. 2. TURBO-GENERATOR UNIT MOUNTED ON A REINFORCED CONCRETE FOUNDATION

In determining the location in elevation of a foundation, allow at least ¾ in. of space between the bottom of the baseplate and the top of the concrete, regardless of the size of the unit. This space will be used for the insertion and adjustment of wedges when leveling up and alining the unit on the foundation. This space is eventually filled with a thick cement grouting which forms an effectual bond and bearing between the rough surfaces of the under side of the baseplate and the top of the concrete foundation.

When installing machines without baseplates it is essential to provide suitable soleplates. These need not be heavy but should be arranged so that the machines can be securely bolted and doweled to them. They may be structural or plate steel or cast iron. The preferred method of installation is to bolt down and dowel the machines to the soleplates and to aline the unit by placing metal wedges or shims under the soleplates. The soleplates should then be thoroughly grouted in position, using care not to disturb the alinement when placing the concrete. If grouting is well done, the unit will be in permanent alinement and at the same time the machines may be easily removed and accurately replaced if ever required.

As a guide in determining the depth to which foundation bolts should be embedded, it may be stated that a smooth headless bolt, embedded to a depth of 40 times its diameter in concrete, will break before pulling loose. If a large washer is used on the lower end, then, of course, the length cast in the concrete may be reduced considerably and still develop the full strength of the bolt.

As soon as the concrete has set, strip off the forms, place the unit on the foundation and carefully level it up. The baseplate may now be grouted in, using a thin mixture of three parts sand to one part cement. Holes are generally provided in the tops of all baseplates for the purpose of running this grouting into place and, with the exception of the necessary cooling air and exhaust pipe passages through it, the baseplate should be completely filled with the grouting. It will be found necessary to build a shallow form all around the edge of the baseplate and on top of the concrete foundation in order to retain the grouting in place while setting. Such baseplates as have passages through them for air to the generator, exhaust piping, etc. will probably require additional interior form construction to retain the grouting. After the grouting has set, remove the shallow forms and steel wedges used in alining and fill up and smooth over any holes left. Do not bring the grouting up around the outside of the baseplate but cut it smooth and even with the bottom of the baseplate so that oil and water will not run under and so that expansion of the baseplate with heat will not crack the cement.

It is generally advisable to paint a concrete foundation with a good oil paint. This should be done when the foundation is new and so prevent its absorption of oil which may result in disintegration.

It always pays to make a study of the manner in which equipment will first be handled upon arrival at its destination. Some small and valuable parts may be stored temporarily in the store house. Large and heavy parts should be placed in such an order and in such a position that they can most easily be taken in the order in which they are to be used in erection. In any event someone should be made responsible for a check of the list of parts received, this check to be made against the shipping list. Any shortage of parts or damaged parts should be reported at once so as not to delay erection later.

Extreme care must be taken not to damage any machined surfaces during unloading. It is much better to use a good manila rope protected from cutting by burlap pads, than it is to use chains. Generally all machined and polished surfaces are covered with a slushing compound which should not be removed until just before the part is required in erection. It can then be easily removed with either benzine or kerosene. Special protection, such as burlap and roofing paper should be removed only to satisfy the purchaser of having received the part in good condition, after which it should be replaced until the piece is required for erection; this is particularly advisable where parts must remain out-of-doors until used.

Alinement Charts for Piping Problems

STEAM VELOCITIES AND PIPE SIZES, EQUIVALENT AREAS AND BOILER EFFICIENCIES CALCULATED GRAPHICALLY. BY LOUIS E. PARTCH

FOLLOWING out the most practical directions as laid out by R. T. Livingston in his articles, "Practical Construction of Alinement Charts," published in three issues of Power Plant Engineering, August 15, September 1 and September 15, 1923, I have constructed several

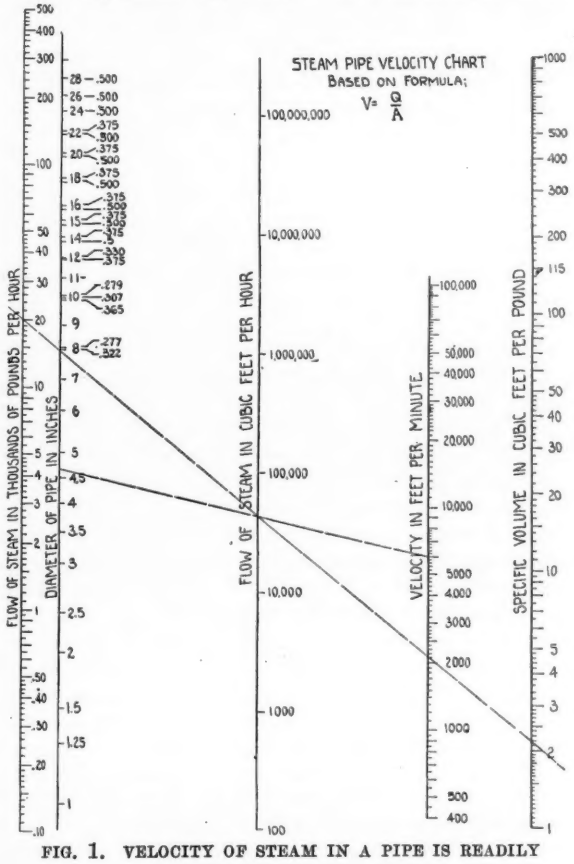

STEAM PIPE VELOCITY CHART
BASED ON FORMULA:
V = Q/A
FLOW OF STEAM IN THOUSANDS OF POUNDS PER HOUR
DIAMETER OF PIPE IN INCHES
FLOW OF STEAM IN CUBIC FEET PER HOUR
VELOCITY IN FEET PER MINUTE
SPECIFIC VOLUME IN CUBIC FEET PER POUND

FIG. 1. VELOCITY OF STEAM IN A PIPE IS READILY OBTAINED FROM THIS CHART

much needed charts that are of considerable value to me in laying out plans for power plants:

Figure 1 illustrates a "Steam Pipe Velocity Chart" that is based on the common formula $V = \frac{Q}{A}$. Q, the quantity, of course is obtained from the product of the pounds of steam per hour and the cubic feet per pound of steam or "Specific Volume" as given in steam tables. A, the area, is laid out to logarithmic scale on the line "Diameter of Pipe in Inches," but as the corresponding pipe size only is of interest, the scale of areas has been omitted. Figure 2, "Steam Pipe Chart," is based on the formula $W = K\sqrt{PY \div L}$ where W is the weight of steam in pounds per hour, K is a factor related to the pipe size, P is the pressure drop, Y is the density and L is the length of the pipe line. This formula is recommended by Gebhardt in Steam Power Plant Engineering and is explained and accompanied by a table of K. Although this chart is intended primarily for use in the determination of high-pressure steam lines, the writer has found that by certain manipulation of quantities, this same chart may be used for air lines, both high pressure and vacuum.

Although Fig. 3 may be somewhat of a digression from the subject of Power Plant Engineering, the writer

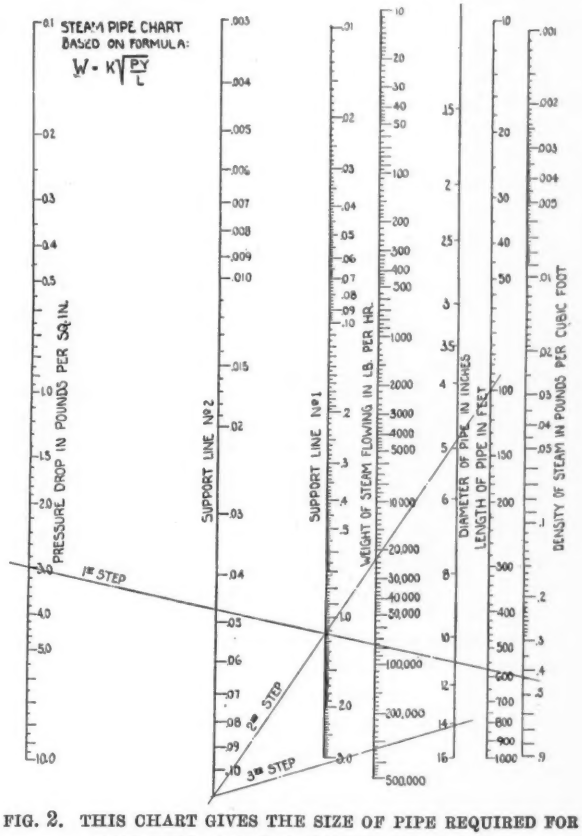

STEAM PIPE CHART
BASED ON FORMULA:
W = K√(PY/L)
PRESSURE DROP IN POUNDS PER SQ. IN.
SUPPORT LINE Nº 2
SUPPORT LINE Nº 1
WEIGHT OF STEAM FLOWING IN LB. PER HR.
DIAMETER OF PIPE IN INCHES
LENGTH OF PIPE IN FEET
DENSITY OF STEAM IN POUNDS PER CUBIC FOOT
1ST STEP
2ND STEP
3RD STEP

FIG. 2. THIS CHART GIVES THE SIZE OF PIPE REQUIRED FOR CONVEYING A GIVEN AMOUNT OF STEAM

has found its construction of considerable interest. No attempt has been made to analyze the construction from the standpoint of mathematics. Quite a number of construction lines were used, however, and instead of worrying over the actual formula, the tables published in Fan Engineering by the Buffalo Forge Co., have been used, For all practical purposes, the curves indicated by the various construction lines were circles and further the radii of the different circles are taken as constant.

Figure 4 is a suggested use of this system of computation in the form of an instrument for indicating the efficiency of a boiler. It is hardly possible that the "machine" can be made entirely automatic as for instance it is quite a problem to obtain the heating value of the coal as fired and connect this quantity to the machine. On the other hand, it is entirely possible to assume, as we do in practice, a constant heating value which we obtain from the most reliable samples and "set" this quantity on the machine from time to time. There are quite a number of troublesome problems in the construction of such a

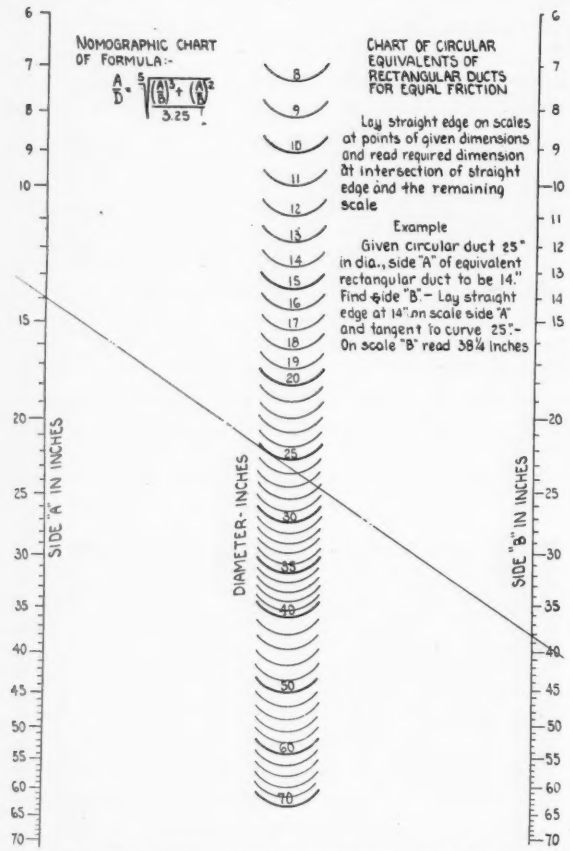

NOMOGRAPHIC CHART OF FORMULA:-
CHART OF CIRCULAR EQUIVALENTS OF RECTANGULAR DUCTS FOR EQUAL FRICTION
Lay straight edge on scales at points of given dimensions and read required dimension at intersection of straight edge and the remaining scale
Example
Given circular duct 25" in dia., side "A" of equivalent rectangular duct to be 14." Find side "B." – Lay straight edge at 14" on scale side "A" and tangent to curve 25"– On scale "B" read 38¾ inches
SIDE "A" IN INCHES
DIAMETER- INCHES
SIDE "B" IN INCHES

FIG. 3. CHART FOR DETERMINING RECTANGLE OF AREA EQUIVALENT TO GIVEN SCALE

machine but in view of the fact that a number of reliable instruments are now available to the average boiler room in which cleverness has certainly been stretched, it seems quite possible to overcome most of the problems. Figure 4 does not take into consideration feed-water temperatures nor coal temperatures nor combustion air temperatures. These considerations naturally add further complications and for all practical purposes, it may be advisable to "set" a number of the controlling values on the machine and merely connect up with such instruments as a steam flow meter and a coal meter.

The practical value of such a machine lies in the fact that the efficiency at the instant is shown and an assembly of readings in this form with the proper connecting levers in plain view, shows the operator what factors are holding down on the efficiency. In reference to accuracy it may be pointed out that it is unnecessary that the actual efficiency be indicated, but a pointer and a single mark would at least show whether the operation was "good" or "bad." On the other hand, it is possible to construct a machine that will be fully as accurate in its operation as a slide rule and with proper scales and graduations, a certain amount of routine calculations may be eliminated from the making out of reports.

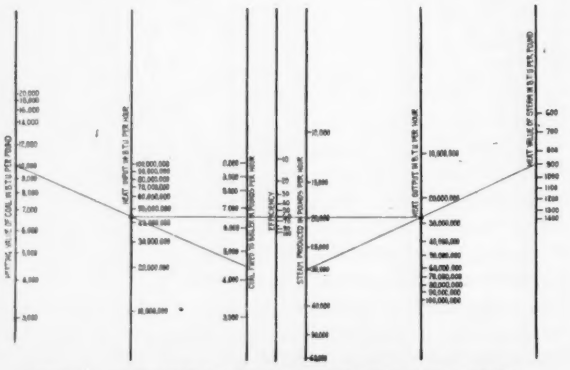


FIG. 4. OUTLINE DIAGRAM SUGGESTED FOR BOILER EFFICIENCY MACHINE

Starting a New Air Compressor

WHEN STARTING a new air compressor fill the cylinder lubricators with the best quality of air compressor oil. Fill the crank case with best quality oil for this purpose, which can be the same oil as is used for the air cylinders. These rules and those which follow are advocated by the Compressed Air Society.

In applying the stuffing-box packing, the joints in the several rings should be staggered. Fill the box with packing and force in slightly with the gland. It is not advisable to use a wrench in drawing up the gland at first as this will crowd the packing, squeezing out the lubricant, causing the packing to become hard enough to score the piston rod. After the compressor is warmed up, tighten the gland just enough to prevent blowing.

Compressors should be turned over several times by hand to make sure that all working parts are free. The proper direction of rotation is always designated on the foundation blueprint furnished by the builder. The compressor should not be brought up to full load immediately but rather should be operated without load for some little time, allowing the working parts to become thoroughly covered with an oil film and careful observation should be made to detect any undue heating. This can be accomplished by opening a valve in the air line or the two indicator cocks on the side of the air cylinders.

Turn on the cooling water, and in the case of a steam machine, open the drain cocks on the steam cylinder and drain the steam pipe above the throttle valve until it is warmed up, then crack open the throttle valve and allow steam to enter the steam cylinder until it is warmed up, turning the compressor over slowly. When well warmed up, gradually bring up to speed and then throw the load on the compressor, at the same time watching the unloading devices to see that they are functioning properly.

Any asbestos sheet packing is suitable for gaskets between air cylinder and heads. The heat of compression and oil gradually soften rubber packing. In replacing gaskets they should be the identical thickness as furnished by builder to insure proper clearance between air piston and cylinder heads.

Good leather belting should be used. Keep shaft centers reasonably far apart to give a good arc of contact on pulleys (15 to 20 ft. centers), and arrange to have slack side of belt on top. Vertical belts should be avoided if possible and be sure the belt runs in the center of the pulleys and that it is not any tighter than necessary to prevent slipping. A tight belt places a heavy load on the bearings, causing them to heat. It also greatly increases the power required to operate. The belt should be from ½ to 1 in. narrower than the face of the belt wheel. New belts are stiff and do not adhere to the pulleys like an old

belt so that trouble is sometimes experienced in starting up a new outfit. A good belt dressing will soften the belt and prevent slippage.

Short belt arrangements are ideal for compressor drives because there is no initial belt tension and little slippage. When the motor is stopped, the belt has no strain. The idler pulley carried on the arms swung from the compressor frame is free to rise or fall and float on the belt, taking up the slack so that the belt contact with the pulleys is increased rather than the tension. Always use a flexible endless belt in connection with the short belt driven arrangement.

Regular inspection should be given at certain intervals at which time any necessary adjustments may be made, such as replacement of worn parts, new packing, taking up the play in working parts and cleaning air valves and crank case. Compressor valves are easily removed for inspection. With the correct lubricant the presence of any deposit on the valves indicates that either the intake air is dirty or that too much oil is being used. Any carbon deposits should be removed and a smaller quantity of oil used in the cylinder. All parts and passages should be examined and any obstructions such as carbon and sticky oil removed. The crank case oil should be renewed at intervals but before changing the oil, the crank case should be thoroughly drained and cleaned. The water jackets should be inspected and washed out as often as necessary instead of waiting until the water space is clogged up tight with mud and other foreign matter.

Some Minor Improvements in a Power Plant

By G. H. Kimball.

SOME time ago it became necessary to install two water tube boilers in the power plant with which the writer is connected. At the time of installation the safety valves on these boilers were not provided with escape pipes to the atmosphere. This caused considerable annoyance due to the boiler room filling up with steam whenever the valves popped, and after considering the matter for a time it was decided to provide an escape pipe.

Since it is usual for only one safety valve to blow where there are two on a boiler, it was decided to equip each boiler with one escape pipe connected to one valve. It was proposed to adjust this valve so that it would blow a little ahead of the other.

When we had one of the new boilers going, the damper regulator not having been connected up, it was difficult for the firemen to prevent the safety valves blowing at certain times. After a time the valve with the escape pipe began to leak badly and it was feared that the weight of the pipe, which was 4 in. in diameter and 15 ft. long, might be exerting a strain upon the body of the valve sufficient to cause distortion of the seat. The opening in the roof was made larger than the outside diameter of the pipe so that no leverage could be exerted by any expansion of the boiler.

When the opportunity came, the valve was taken apart for repairs and the guide cylinder was found badly scaled so that it was difficult for it to move up when the valve opened. This was cleaned, and the valve ground and the leaking stopped.

To remove any chance of the weight of the escape pipe affecting the valve, the arrangement, shown in Fig. 1, was made. In planning the installation of the boilers, it was found that more head room would be desirable, so a large monitor was constructed standing about 5 ft. above the old roof. This allowed ample head room over the boiler settings but it did not run beyond the space taken by them. In the figure, the beams B supported the old roof and the monitor roof is shown above them. The safety valve A with the escape pipe is shown and it was necessary to pipe the drain to the ashpit since considerable water came out at times.

To support the pipe proved to be a simple problem and the beams B were found convenient for this purpose. It was felt, however, that a rigid support when the boiler was hot might be too rigid when the fire was out and the boiler and setting might drop to some extent putting some strain on the safety valve. Figures 1, 2 and 3 show different views of the support, which was made of two 2 in.

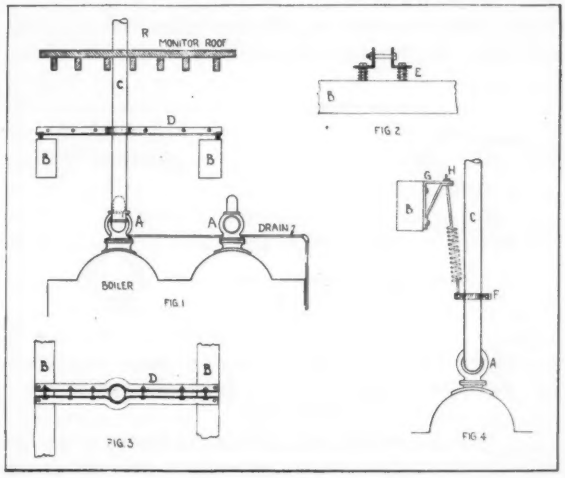


FIG. 1-4. METHOD OF SUPPORTING SAFETY VALVE VENT PIPE

angle irons bolted together and curved around the pipe. At the ends were two lag screws running into the timbers B and each screw was put through a heavy coil spring E as shown in Fig. 2.

The method of procedure was as follows: The bolts on the bar D that held it together so that it would clamp the pipe, were loosened; then the four lag screws at the ends were tightened so that the springs would be compressed. The bolts on the bar D were next tightened and after that the lag screws were backed out which allowed the springs to exert a lifting force at each end of the bar. It was necessary to unscrew the lags only about a quarter of an inch after which the weight of the pipe was supported largely by the springs.

On the second boiler, the room beam B came within 6 in. of the escape pipe so that a long supporting bar was not needed. The device shown in Fig. 4 therefore was made. This is self-explanatory for the bracket G was bolted to the beam B and the clamp F was bolted to the pipe C. Then the heavy spring with the rod fitted with an eye on one end and one with the nut H on the other was connected up and a tension put upon the pipe which helped support the weight.

The damper regulator was one of many years standing and had a short travel piston. The new damper was hung on a ball bearing on a vertical spindle and the travel of the lever was greater than that of the regulator piston. To gain travel without purchasing a new regulator, the device shown in Fig. 5 was made. The customary wire ropes were connected to the damper lever and to the regulator and the first one was run to the large sheave wheel A. The smaller wheel B was keyed to the same hollow spindle and it had the rope R connected to it. The wheels turned on a stud fastened to the bar C and the whole assembly was bolted to the wall of the boiler room. With this arrangement it is evident that an inch movement of the damper regulator piston would move the damper lever about an inch and one-half.

As soon as the above was completed it was found that the increased load placed on the damper regulator made it difficult to work with the city water pressure that was available. This pressure varied from 50 lb. per sq. in. at night to as low as 25 lb. at times during the day. The idea of connecting it to the feed line was considered and then two questions came up. First, whether the regulator would stand the pressure of 125 lb. and then in winter

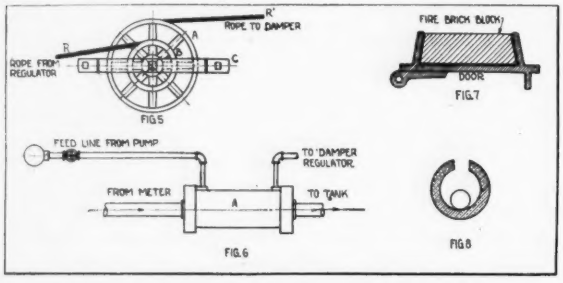


FIG. 5. ARRANGEMENT USED TO INCREASE TRAVEL OF REGULATOR

FIG. 6. COOLER FOR REGULATOR WATER

FIG. 7. DOOR LINING WITH SOLID BLOCK OF FIRE BRICK

FIG. 8. CONDUIT FOR CAPILLARY TUBES

when the returns from the heating system were being pumped, would the hot water cause trouble with the leather packings in the piston?

The makers of the regulator said that it would run with the increased pressure and to cool the water in winter, the arrangement shown in Fig. 6 was constructed. A is a very small coil heater, made for use in residences to heat water from a heating boiler.

A quarter inch connection was taken from the feed line from the pump before it went through the heater and then running through the coil inside of A then to the damper regulator. For cooling water, the water from the city meter was piped through A and then allowed to run to the feed tank for makeup or anything else where it would be needed. This arrangement kept the water for the regulator cool at all times.

Door Lining

In Fig. 7 is shown view of the side door for a hand stoker to be used to facilitate cleaning the fire. These were first lined with fire brick but due to the joints, they did not last long. After communicating with a well known concern that manufactures fire box linings, it was found that they would make up some solid blocks of fire brick to use as linings. In due time these arrived and were found to be a great success. They need to be a very loose fit and they will run for many months before cracking. Also it requires little time to put in a new one.

Conduit for Capillary Tubes

Having provided boiler meters with recording pyrometers, it was thought best to protect the copper capillary tubes as well as possible. To this end it was decided to take ½-in. pipe and mill a slot as shown in Fig. 8. This slot was slightly smaller than the diameter of the capillary and it was sprung apart enough to slip it inside and then clipped to the setting wall in the position as shown. By this means the tube is well protected. To forestall the question as to why the tube was not pulled through endways, it is well to remember that pyrometer shell that goes inside of the setting has the tube connected to it and on the other end is the connection for the meter with a long mercury reservoir. All of this is made up in the factory and cannot be taken apart on the ground.

Questionnaire Aids in Building Up Boiler Efficiency

BOILER equipment in many industrial plants is small and it is often neglected, not necessarily because of too little knowledge about combustion or the technic of boiler room practice but rather due to the indifference that is shown to the cost of various small items that go into the cost of manufacturing. This is the conclusion reached by C. L. C. Kah in his paper prepared for the 32nd annual meeting of the Michigan Gas Association which was held in Detroit on September 10 and 11.

To overcome this condition he suggests a series of 13 questions, the answers to which if properly arrived at, will readily show wherein losses are occurring and thus facilitate their elimination. These questions, with abstracts of the discussion, are as follows:

What is the efficiency of the boiler? This should be shown as the ratio of heat absorbed to heat furnished. It is not sufficient to know only the pounds of water evaporated per pound of fuel because if that is low, one would not know whether it was due to inefficiency of the boiler or poor fuel.

What is the efficiency of the furnace? This should be stated as the ratio of the gases completely burned to the combustible gases generated in the fuel bed. The space above the fuel bed must be deep enough so that the gases are completely burned before they strike the comparatively cool boiler shell.

How much air is leaking through your boiler settings? Ordinarily, air for complete combustion of CO must be supplied as secondary air, which can be admitted at the fire doors just above the fuel bed. Fire doors are usually fitted with dampers for the purpose of adjusting the amount of secondary air admitted. Unfortunately most boiler fronts are in such condition that there is little cause to worry about not enough secondary air.

How thick should the fuel you are using be fired? It is readily noted that the amount of CO evolved is controlled by the thickness of the fire. What the thickness of fuel bed should be for best efficiency must be determined experimentally. For standard boilers the grate area has

been determined arbitrarily in proportion to heating surface for using coal, if boilers are working near their rated capacity it is often difficult and sometimes impossible to carry the load when firing breeze or coke. This may be overcome by moving the bridge wall back and increasing the grate area. The grate surface should be increased so that at maximum load not more than 10 lb. of fixed carbon is burned per square foot of grate surface.

Should the fuel fired be wet or dry for greatest economy? Ordinarily the drier the better; however, wastage through the grates can often be stopped by slightly dampening the fuel before firing it.

Is the grate surface right for highest economy? Temperature of the fuel bed is determined by the rate of combustion. An effective way of reducing clinkering is to increase the grate area thereby lowering the rate of combustion per unit area of grate surface.

How much combustible is left in the ash? With herringbone grates with ½-in. air space and ½-in. bars not more than 6 per cent combustible should be left in the ash when burning coke breeze.

Does your fireman know how to take care of the drafts properly to care for the variation of loads efficiently?

Is internal inspection made frequently?

Is the temperature of the feed water entering the boilers as high as it is possible to get under given conditions?

How much steam is being wasted? What do leakage and radiation losses amount to? Is steam being wasted by inefficient apparatus? Having done all possible to produce steam economically all wasteful equipment must be studied with the point in view of saving steam.

In a discussion of this paper by Chas. A. Hamilton it was stated that the fireman should remember that his job is to make steam and not merely burn coal. He should be willing to learn and to try out suggested improvements. At the same time the plant owner should appreciate the possible increase in efficiency of steam production and use and encourage his operating force by showing appreciation for results obtained.

Importance of Nozzle Arrangement in Spray Ponds*

IN SOME of the larger spray ponds installed recently, it has been found that although they were laid out according to what might be termed standard design, the cooling effect in the center and on the leeward side of the pond was considerably less than on the windward side. This condition was caused by a blanketing effect of the nozzle spray which prevented air from reaching nozzles in the center and on the leeward side of the pond. In one particular pond the difference in cooling range between the center and the windward side of the pond amounted to as much as seven deg., when the cooling range of nozzles nearest the wind was 14 deg. In another pond where wide air lanes were put in between every five or six rows of nozzle clusters, the maximum difference between the center and outside edge of the pond was found to be only 3 deg.

In following up this matter it was hoped that by obtaining operating data from various installations specific deductions might be drawn as to the proper spacing of nozzles and the necessity for large air lanes as the size of ponds is increased. Unfortunately only meagre information has been secured in connection with this phase of the subject, the principal reason being that few companies have any daily operating data in connection with spray ponds and others, who have logged their operation, have done it only from the standpoint of overall results or in an endeavor to check up the manufacturer's guarantee. It is well to impress upon those who operate spray ponds the necessity of checking up the results obtained in various parts of the pond. This can be done only during warm weather when it is possible for a man to observe the temperature of the water at the water's edge in different parts of the pond. In obtaining the temperature of the sprayed water it is necessary to catch it in a shallow pan just above the water's edge. The pan should be shallow enough to permit the water to run continually over its side, but to allow a thermometer to be used to obtain the final temperature of the sprayed water.

Most of the larger ponds are laid out on the theory that the present standard distance between headers (26 ft.) and between individual nozzle clusters (13 ft.) is sufficient to allow free access of air for cooling. It is felt that there is a limit to the size of pond which will work satisfactorily with the spacings just mentioned, and in the layout of a large pond there should be considered the necessity of providing large longitudinal and transverse lanes so as to allow air to reach all portions of the pond. The design in mind is one similar to a checkerboard.

Fine Spray May Cause Blanketing

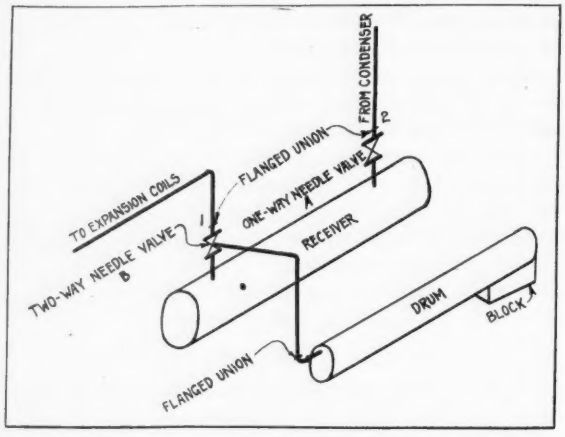
It is generally believed that the finer the spray emitted by a nozzle the better the resultant cooling. It may be true that a nozzle with a very fine spray will give slightly better cooling than one with a coarser spray; still, when nozzles are collected in large groups the spray may be so fine as to produce a blanketing effect which will exclude the air from the center nozzles and thus produce poorer overall results than could be obtained from nozzles with a somewhat coarser spray. The fineness of spray must also be considered where driftage, due to wind, is likely to be serious, as in congested districts, or where the makeup water is limited. Generally speaking, the finer the spray and the higher the distance the spray is thrown, the greater will be the loss due to driftage.

In some localities conditions are favorable to the development of vegetable growth in spray ponds. This growth of algae has been retarded by introducing copper sulphate into the pond. Generally the sulphate is placed in a burlap bag and hung in the pond at a point where the water is continually flowing past the bag. The cost of treating water in order to prevent the growth of algae is very slight. Another recommended method of treatment based upon the generation of formaldehyde in the water, is to put into the pond one pint of wood alcohol and one pound of permanganate of potash crystals dissolved in water, for each 35,000 gal. of water in the pond. This solution is poured slowly into the stream of water entering the cooling pond from the pumps, thereby thoroughly mixing with the water and killing the vegetable growth. The dose is repeated once a month for average conditions. It is reported that this treatment is not in any way detrimental to steel, iron, brass, concrete or wood.

*Statement by M. F. Stack of the Electric Bond & Share Co. in the recent report of the Sub-committee on Condensing Equipment of the Prime Movers Committee of the N. E. L. A.

Charging Ammonia System

RECENT articles relative to charging ammonia systems have described methods different from mine. My experience has been that the fewer valves and fittings you have, the less chance you have for trouble. With the connections shown in the sketch, any attendant can charge a



CONNECTIONS THAT FACILITATE CHARGING, SHOWING UNIONS AND VALVES

drum of ammonia into the system without making a mistake. In the sketches that I have seen in previous issues, if it were necessary for the receiver to be moved, there is not a union on the lines.

Referring to the sketch, 1, 2, 3 are unions, A is a needle stop valve and B is a two-way needle stop valve.

When ammonia is needed, the drum is inclined about 4 or 5 in. and connected so that the connection from the cylinder is at the top, as more ammonia has been left in the drums by not having the drum in the right position than from any other cause. Next the valve to the receiver is closed and the valve to the drum cracked. If there is no leak between the receiver and the drum, the valve to the expansion coils and the stop cock of the drum are opened. When the drum is nearly empty, the ammonia vaporizes and can be heard as it travels from the drum to the system. It will then frost on the bottom of the drum and on the pipe to the expansion valve. I do not believe that pumping a vacuum on the drum pays, as the power is worth many times the small amount of ammonia left.

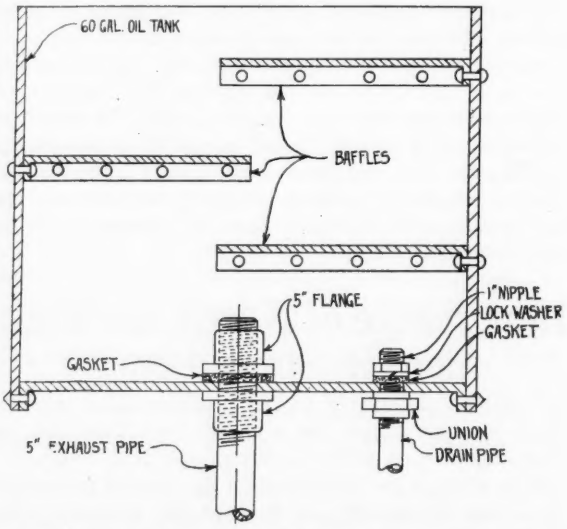
Regarding the back pressure, I have been informed that the machine builders base their tonnage on 15 lb. back pressure and 185 lb. head pressure but some machines will stand more than others. I operated one machine on a flooded type system with 45 and 50 lb. back pressure and got 13 T. of ice out of a 10-T. plant. I think this is a question that each engineer will have to figure out for himself, as this is not a very good way of telling just how much back pressure to carry on the individual plant when the operating conditions are not known.

By keeping the drum on a rack outside of the building and charging from there, if convenient, a lot of time and labor will be saved. If there is any trouble, the ammonia will escape to the air and not into the building. If a drum should explode the results would not be as serious as if it were in the plant.

Malvern, Ark. W. H. HOWZE.

The Manager Bought a Separator

SOMETIMES an engineer will put the blame on the manager for any trouble that may come up. One will often hear this expression: "Well, I told the boss about it and he paid no attention to me." It is part of human nature to "pass the buck," but I had an experience not long ago that I want to tell you about.



HOME-MADE TANK FOR COLLECTING WATER IN ENGINE EXHAUST

I have under my care an engine and two 250-hp. Heine boilers as well as the pumps and other machinery in a large factory. We did not have a separator on the steam line from the boilers to the engine. This I knew was badly needed, so I went to the manager about it. He said we could not afford it, that times were too hard and besides he just couldn't see where it would save any money.

I didn't give up, however. I took an old 60-gal. oil tank, cut a 5-in. hole in the center of the bottom of it and a 1-in. drain hole. Then I riveted several semi-circular

sheet iron baffles in the tank, as shown in the sketch. By screwing a 5-in. flange on the exhaust pipe as shown, placing the tank over the pipe so it rested on the flange, and clamping the whole with a second 5-in. flange with a gasket under it, I secured a water-tight connection between the exhaust pipe and the tank. Next I fitted a drain pipe to the 1-in. hole in the tank through a nipple, running the drain pipe down the wall so it could be reached from the yard.

The first day I collected ½ gal. of condensate to the minute or 30 gal. an hour, or 300 gal. in a day of 10 hr. This didn't look quite as good as I had expected, but the next day I made another test and collected condensate at the rate of 400 gal. per day. I waited a day or two and, when the boiler showed a little sign of priming and there was a little slapping in the cylinder, I made another test and got 700 gal. per day.

That satisfied me. So I started figuring and had it right before me on paper. I had also become conversant enough with the subject to talk and know what I was talking about.

Not long after this, the manager came through the engine room and wanted to know where all the water was coming from that was running out across the yard. I told him that was what I had been wanting him to ask me for some time. Then I showed him the figures and told him what I knew about it. He ordered my steam separator and it is now doing good service.

South Boston, Va. F. T. HUNT.

Note—Mr. Hunt's device enabled him to prove to the manager that too much water was coming through the engine and that a separator in the main steam line would keep out most of it. At the same time it should be remembered that all the water that collected in the tank was not entrained water from the main steam line, but that some of it was due to condensation in the engine cylinder, in the exhaust pipe and in the collector itself.—Editor.

Removing Static Electricity

POWER transmission belts sometimes give trouble due to static electricity. Disastrous fires and explosions have been caused by static sparks, usually in dusty and gaseous surroundings.

Static, however, can usually be avoided without great difficulty. One of the ways is to keep the belt "damp" and as good a way as any is to use a dependable belt dressing which will work its way through the belt and keep it nice and soft and pliable. Do not overdo the treatment, however, because by using too much dressing the belt is likely to slip and if the belt slips, static is liable to be produced again.

Friction, high speed dry belts, dry air, surrounding iron structures, etc., are all contributory causes of static electricity but friction is the principal cause, therefore the principal thing to eliminate is the belt slip.

If the static electricity is not stopped by this method, it can be led away through a copper wire by "combing" it off the belt by means of fine copper wire suspended so as to touch the belt at the mid-point between the pulleys. Also allow the ends of a comb to touch the bottom of the belt while running but do not allow the pressure of the wires on either side to be great enough to scratch or injure the belt in any way. All that is needed is contact, not pressure. It has been determined experimentally that the best location for this comb is about halfway between the pulleys.

The wires should then be grounded to a pipe or to anything metallic that runs into the ground or run a wire into the ground for the express purpose of taking care of the static. No more trouble will be experienced.

N. G. NEAR.

Repair to Plate Ice Expansion Coils

THIS PLANT had a daily capacity of 120 T. of ice, size of sheets 12 by 20 ft., weighing 5 T. each. Connections between the header and expansion coils in the tank were made in a rigid straight line. Three of these expansion coils, where they came through the side of the tank, had been broken off at the point shown in the accompanying

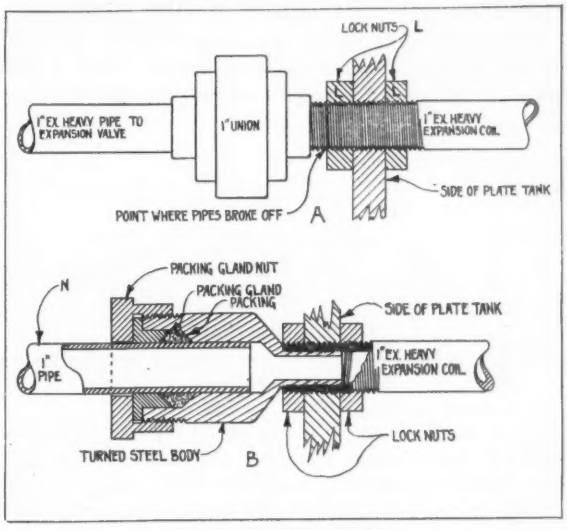


PLATE ICE COIL REPAIR

sketch, A. These three coils had been out of service for a long time, as the engineer said repairs could not be made without shutting down and pumping out all the coils, which would mean a loss of a day or more of the whole output of the plant.

After a change of engineers, repairs were made as shown in sketch B. The insides of the 1-in. extra heavy expansion coils were tapped out with a ¾-in. pipe tap at the point where they were broken off. Stuffing-boxes were made up as shown and were screwed into the expansion coils, after which the 1-in. nipple was screwed into the valve and through the gland nut made up tight on the packing.

This made it possible to put these three coils in service without a minute's shut-down and gave the plant the advantage of the extra 15 T. of ice.

Arlington, N. J. GEO. C. WELLS.

Charging the Ammonia System

WHAT G. U. Swann writes in the October 15 issue under the above heading reminds me of a method employed at one time by an associate engineer in charging an intermittent system of refrigeration. The pressure in the system was equal to the pressure in the drum, consequently he could not get a flow of ammonia.

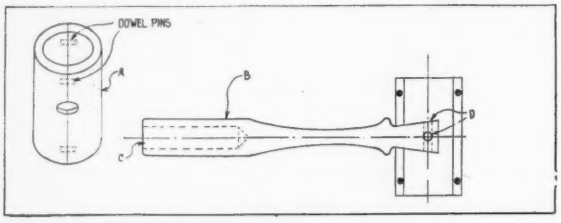
To compel the flow he built a fire beneath the ammonia drum, using old newspapers and carefully watching and listening so that the pressure would not be increased too much.

As most users of ammonia know, it does not require much heat to increase the pressure in an ammonia drum, and whereas this method might be considered dangerous by some, still by exercising care it is practical and I should say that it is not unsafe when used by a skilled engineer. In fact, if the drum is only 1 deg. warmer than the receiver in the refrigerating system, the ammonia will eventually pass from the drum into the receiver, because according to all ammonia tables the pressure corresponding to a higher temperature is always greater than the pressure corresponding to a lower temperature.

Newark, N. J. W. F. SCHAPHORST.

Soft Hammer Made From Babbit

FOR THE shop or engine room, a serviceable soft hammer can be made out of scrap babbit metal. First, a split wooden mold for the head is made of the desired shape



MOLD FOR HAMMER HEAD WITH HANDLE FITTED READY FOR POURING

and size as shown at A in the sketch and fitted with a handle B, turned from a piece of old shafting. (A piece of pipe could be used but would not be as good.) A hole is bored in the end of the handle at C to lighten it, while the holes D, at right angles to each other, will allow the metal to flow through them when the mold is poured, thus locking the handle more securely in place.

Now, by fitting the wooden mold over the handle, as shown, and pouring melted babbit into the mold, the hammer can be completed. If the babbit to be used is soft, nothing need be added to it but if a hard, brittle grade is used, a little lead mixed with it will prevent it from chipping.

Louisville, Ky. A. R. KNAPP.

My Educational Sinking Fund

AS READERS of Power Plant Engineering may have noticed I quite frequently contribute short articles for publication. The compensation which I receive for this work, over a year's time, mounts up to an appreciable sum. This money I call my educational fund and I use it to renew subscriptions to engineering journals which I take and to add to my technical library.

All I do to earn this income is to keep my eyes and ears open and my mind alert to notice and record any new idea, wrinkle, kink, or other matter which I believe would be of interest and value to Power Plant Engineering readers and later write out a description and send it to the editor.

On doing this I not only increase my income but also my fund of worthwhile knowledge. It is also worth something to know that these ideas which have helped me will also be a help to others who may read about them. It is impossible to help others in this way and receive no personal benefit from the mental effort necessary to produce such written articles.

Several times I have received letters from engineers who have read some article of mine and it has been of considerable value to them. When this occurs, I am even more pleased than I am when I receive a check from a publishing office.

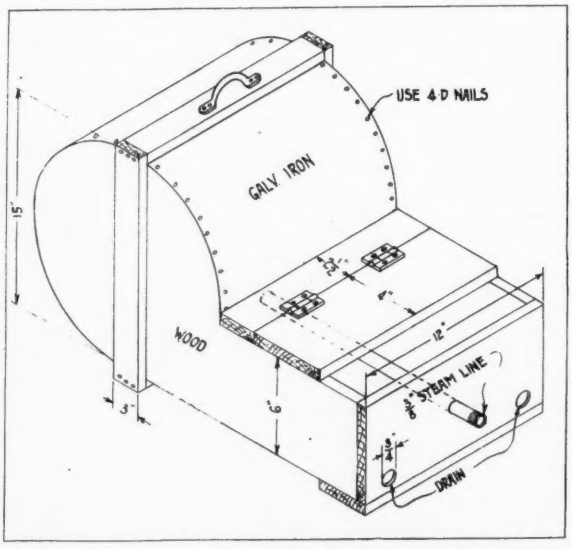
Every experienced engineer has stored away in his brain some valuable idea that is of no use to him in its present dormant state but if it were put into print, it would be of considerable value to some other fellow. It has always been a puzzle to me to understand why such men persist in hoarding such knowledge.

I know of nothing that can be of more value to an engineer than the correspondence section of his engineering journal. It is the unusual but simple idea that is of value.

Toronto, Ont. JAMES E. NOBLE.

Clothes Washer for the Power Plant

FOR WASHING overalls or other garments in the power plant, the washing machine shown in the sketch can be easily constructed and will prove convenient. One of these



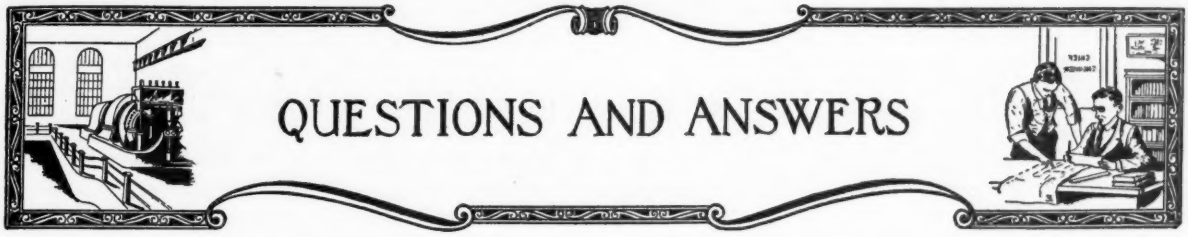
WASHING MACHINE, SHOWING CONSTRUCTION OF TANK, AND STEAM CONNECTION

machines has been in use at our plant for 3 yr., washing an average of five suits each week.

Before putting garments into the washer, soak them for an hour in hot water that contains some good washing powder or soap chips. Then drain the clothes, put one garment at a time into the washer while it is still wet and turn on enough steam to make the garment "loop-the-loop" 40 to 50 times a minute for 2 or 3 min. rinse the garment through two or three changes of cold water.

For a steam supply we use a connection from the flue-blower.

Circleville, Ohio. M. E. CAROTHERS.



Starting a Cold Turbine

SUPPOSE that we are required to start a turbine (vertical or horizontal) that has been idle for three months or more and is stone cold. We are required to get the machine into service as soon as possible to help out on the load. What are the important things to be done and the dangers to be guarded against, in order to get the unit under way quickly but at the same time in perfect safety?

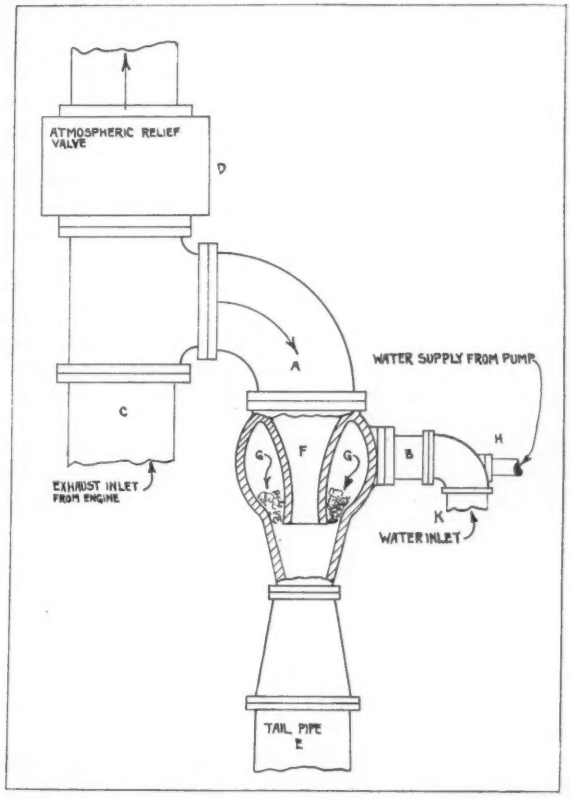
W. H. K.

Why Condenser Vacuum Pump Races

ONE OF THE chief causes for the trouble O. W. H. has with the vacuum pump on a barometric condenser, described in the October 15 issue, is neglect to clean out the rubbish which gets into the water chamber of the condenser back of the nozzle, as shown in the sketch at G-G. This rubbish chokes up the small passage-way and prevents sufficient water passing to condense the steam as it comes from the engine in fluctuating volume. The load on all engines varies and for an early cutoff there is less steam exhausted to the condenser than with a later cutoff. With the short cutoff, even though the passageway G-G is partially choked up, there may be sufficient water still going through to condense this amount of steam. But when the cutoff comes later the volume of steam is greater and the water passing through the partly open inlet valve and choked passage G-G is insufficient for condensing the larger volume; this puts a back pressure on the condenser equal to that required to open the atmospheric relief valve—possibly 18 lb. absolute. This increases the work of the vacuum pump and the weight of the water in the discharge pipe from pump to condenser is added to the 18 lb. absolute pressure. This sudden change occurring in the space of a few seconds reduces the speed of the vacuum pump, the vacuum slightly decreasing until the volume of water is forced into the condenser and falls down the tail pipe, condensing the steam as it does so. The weight of the water in the tail pipe forms a partial vacuum, which relieves the atmospheric pressure on the discharge pipe of the vacuum pump and it races.

While this is going on, great changes are occurring in the engine cutoff, as the governor, automatically shifting to maintain normal speed, sets the cutoff at full limit. A full cylinder exhaust of steam is now sent into the condenser and since the volume of water is the same, the condenser cannot condense this volume of steam so that the vacuum is lost entirely. The shut-down allows the condenser to operate without the steam entering, the vacuum is built up again and all is well until the heavy load is again thrown on the engine.

These condensers have a small range through which the amount of inlet water can be varied. Too much water will flood the condenser, while too little water leaves the tail pipe unfilled. If the tail pipe is not full of water and the end submerged below the surface of the water in the hot-well air will enter the tail pipe and the vacuum will be lost. It seems that this condenser is large enough for the size of the engine unless it is badly overloaded but unless water can pass through the passage ways G-G, the steam cannot be condensed and the vacuum pump may be working against undue pressure from friction caused by such obstructions.



SIPHON OR BAROMETRIC CONDENSER, SHOWING HOW NOZZLE CAN BE CLOGGED BY RUBBISH

In the fall of the year nearly all brooks or rivers are filled with leaves and in spite of screens much of this refuse gets into the condensers. Only on large sizes of these condensers are proper hand-hold clean-out openings made. The size illustrated is commonly used on engines of less than 100 hp. To clean them it is necessary to remove the elbow A, which is quite a job for one attendant, requiring the removal and replacing of many bolts and two new gaskets. Hook rods can be put down through the nozzle F to rake out much of the rubbish from the lower side of the passage-ways. As the water inlet pipe is much smaller, a flanged nipple placed at B is more

easily removed so that hook rods can be inserted around the outside of the nozzle F to clean the passages.

It is far better to connect a removable strainer in the water-inlet line, which would collect all rubbish that happens to get by the water-inlet well-screens. The size of the rubbish which could pass these small-mesh strainers would pass the small passage-way around the nozzle F in the condenser. These strainers can be cleaned alternately, without interference with service.

In many cases trouble is not caused by rubbish from the brooks which supply condensing water, but by the broken pump valves, springs and old pieces of gaskets left in the pipe lines when repairs have been made. When valves in the vacuum pump break they are generally found in this chamber unless there is a stop valve between the pump and condenser, in which large pieces of valves may lodge, to choke up the line and prevent sufficient water passing to condense the steam.

If the vacuum pump is of a type which has tappets on the valve rod, the packing on this rod becomes worn and the rod moves too freely. Unless the stuffing-box is screwed up quite tightly, there may be some short stroking of the vacuum pump, which may cause the pump to slow up for a stroke or two. The resultant decrease of vacuum would cause it to race on the next few strokes, but if this trouble occurs, the vacuum pump will often stop entirely and will be found so after the vacuum is lost and the engine shut down. If the valve rod has become badly worn in the stuffing-box, a new rod should be put in, as a worn rod will cut the packing out of the stuffing-box and cause short stroking of the pump, loss of vacuum or shut-down of the plant. Where the inlet water all passes through the vacuum pump to supply a barometric condenser, valves which break while the condenser is in operation are not easily detected from the action of the pump, as the vacuum which the condenser maintains allows the atmospheric pressure to force the water up into and through the pump to the condenser. Therefore the trouble with the vacuum pump is not discovered until it is to be started after a shut-down.

I suggest that O. W. H. examine the passage-way G-G in his condenser. I think he will find the cause of the trouble there.

Cambridge, Mass. R. A. CULTRA.

Reducing Bag in Boiler Sheets

WHAT CAUSES boiler sheets to bag and how can bagged sheets be repaired?

2. Why is an open feed-water heater set higher than the feed pump? G. B.

A. Boiler sheets become bagged when they become overheated. When overheating occurs, the tensile strength of the metal is materially reduced and the internal pressure, acting on the boiler, distorts the sheet. This overheating is usually caused by an accumulation of scale on the inside of a sheet that is directly exposed to the heat of the furnace.

To prevent a boiler from becoming bagged, then, it is essential that the water surfaces, particularly those exposed to the radiant heat of the fire, be kept in a clean condition.

If the bag has not developed to too great an extent, it may be repaired by drilling a hole in the center of the bulged section and after heating the part to a dull red by means of a blacksmith's forge, or some other suitable means of applying heat, by hammering it back into shape, starting at the outer edge and gradually working in toward the center. It may be necessary to repeat this process several times before the bulge can be entirely reduced. When the sheet has been hammered back into its original position, the hole in the center should be re-drilled and plugged with a rivet.

2. Theoretically, a water pump can lift water by suction to a height of 34 ft. In actual practice, where cold water is used, this height is limited to about 25 ft. As the temperature of the water increases, the lift must be decreased because, as the pump is brought into operation, a partial vacuum is formed in the suction line and the boiling point of the water is reduced. If the pressure is reduced far enough, some of the water is converted into steam and the vacuum is no longer effective. When you are handling water at a temperature of 212 deg., there can be no suction lift; as a matter of fact there should be a positive head of 4 or 5 ft. on the suction of the pump to insure proper operation; for this reason, then, feed-water pumps are placed below feed-water heaters.

Problems in Steam Consumption and Engine Operation

STEAM IS delivered to six japanning ovens at 80 lb. boiler pressure. Each oven has 250 sq. ft. of 1-in. pipe coil, or a total of 1500 sq. ft. Each oven is connected with an exhaust outlet, and also a circulating fan overhead. The ovens will measure about 6 ft. square and 7 ft. high. The thermometers on the ovens show a temperature of 240 to 250 deg. There is an opening at the bottom of each door, between the door and floor, of 4 by 26 in. The ovens are made of ½-in. sheathing, tin lined inside. Room temperature averages 75 deg.

How can I figure a fair coal consumption for these units, with coal having a 13,000-B.t.u. heat content and boiler efficiency 60 per cent? Returns are saved and delivered back to boiler.

2. Please explain "Heat Balance."

3. How can I determine the allowable size of hole, to drill in a pipe or fitting? I want to drill and tap a 6-in. ell and an 8-in. standard tee.

4. Suppose you had finished setting the valves on a Corliss engine, and you were ready to set knock-off cams for cutoff. How would you know where to set for cutoff to pull the load? Does a given cutoff mean you can do a certain amount of work, or develop a given horsepower; if so, how is this determined?

5. What condition would tend to throw a pendulum governor out of balance, and what bad effects would this have on the governor, and its operation? Would it affect engine speed?

6. What kind of results would you expect from a pendulum governor, if one of the flyballs came off?

7. Suppose you changed from non-condensing to condensing, and vice-versa. What changes would be necessary on the valve adjustment, and why?

8. How can I figure the water rate for any engine?

9. What causes the "critical speed" in a turbine? Can this be overcome in their manufacture?

10. What is meant by a 1-2-3, etc., stage centrifugal pump? What object is there in building pumps of this style? L. B.

ANSWERS

1. Ordinarily it may be assumed that the co-efficient of heat transmission from steam to air in the ordinary heating coil will be about 2 B.t.u. per sq. ft. of surface per degree difference in temperature per hr. If then you have a total of 1500 sq. ft. of heating surface, the heat transmitted will amount to $2 \times 1500 = 3000$ B.t.u. per degree per hr. Steam at a gage pressure of 80 lb. has a temperature of 324 deg. and inasmuch as the temperature of your oven is 240 deg. the temperature difference is 84 deg. and the total heat transmission will be $3000 \times 84 = 252{,}000$ B.t.u. per hr.

If all the condensate is returned directly to the boiler the heat available is simply the heat of vaporization of the steam, which at the pressure mentioned is approximately 891 B.t.u. per lb. The steam requirements of your oven then will amount to $252{,}000 \div 891 = 283$ lb. per hr. If you are burning 13,000 B.t.u. coal with an overall efficiency of 60 per cent the coal requirements to supply this amount of steam will be $252{,}000 \div 13{,}000 \div 0.60 = 32.3$ lb. per hr.

2. A heat balance is an itemized account of the heat uses and losses in any given piece of apparatus, or in the plant as a whole. To make up the heat balance it is simply necessary to take each piece of steam using equipment in turn, and to determine what proportion of steam is used for conversion into work, and what part is dissipated as loss. The usual heat balance sheet ordinarily takes the form given below—(expressed as B.t.u. per lb. of coal as fired):

(1) Heat units in coal
(2) Boiler losses
  (a) Loss due to evaporation of moisture in coal
  (b) Loss due to heat carried away by steam formed by the burning of hydrogen.
  (c) Loss due to heat carried away in the dry flue gases.
  (d) Loss due to carbon monoxide
  (e) Loss due to combustible in ash and refuse
  (f) Loss due to heating moisture in air
  (g) Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for
  (h) Heat supplied steam driven appliances for operating boilers less that recovered by heating feed water.
  (i) Total boiler losses
(3) Engine consumption
  (a) Radiation from steam pipe
  (b) Radiation from engine or turbine
  (c) Heat rejected to condenser
  (d) Heat withdrawn from engine receivers or turbine stages or other use than heating feed water
  (e) Heat lost by leakage of steam piping
  (f) Heat converted into work
(4) Heat in steam supplied for purposes foreign to engine or turbine
Totals (same as Item 1)

3. Ordinarily it is not considered wise to tap a hole in any pipe fitting. While it may be permissible to tap a hole up to ¼ in. nominal size in the fittings which you mention, if anything larger than this is contemplated it would be well to use a special fitting with standard outlets, such as you may require.

4. The normal cutoff of any engine is ordinarily set with the governor in about the middle position. Suppose that from a consideration of the power requirements and the mean effective pressure we find that your engine at the desired speed will have to be cut off at ¼ stroke. Then it is simply a matter of blocking your governor in the running position and setting the cutoff gear to release at this point.

5. Breakage of the compensating spring on any governor would throw the apparatus out of balance, and would result in an unbalance of the forces acting such that the cutoff would be shortened. With the normal load on the engine, this, of course, would result in reduced speed.

6. The loss of a ball on a flyball governor would throw the governor out of balance, and would reduce the force available for actuating the cutoff mechanism, resulting, probably, in the engine going at runaway speed.

7. If an engine carrying a constant load is changed from non-condensing operation to condensing operation, the cutoff would be shortened and compression should be retarded.

8. The most trustworthy method of determining the water rate of an engine is to condense and weigh the exhaust for a definite period of time, during which the horsepower-hours output can be accurately ascertained.

9. The critical speed of a turbine is ordinarily defined as the speed at which the rotor ceases to revolve about the geometrical center and begins to revolve about its center of gravity. Unless these two centers coincide exactly there is a noticeable disturbance in the operation of the machine. There is a slight discrepancy in most high speed units in this respect, but by extremely careful workmanship it would be possible to make them coincide so that there would be no noticeable critical speed.

10. The pressure which it is possible to attain with a centrifugal pump depends upon the peripheral speed of the rotor. Obviously it is wise to limit the peripheral and rotative speed of the rotor, consquently there is a limit to the pressure which can be obtained with a single speed unit. If high pressures are desired all that is necessary is to use two units in series, one taking its suction from the discharge of the other. This is virtually what happens in a multi-stage centrifugal pump. Two, three or four independent pumps are arranged side by side on the same shaft and are hydraulically connected in series.

Size of Receiver Safety Valve

HOW CAN I find the correct size of safety valve for the receiver of a compound engine? J. A. S.

A. The correct size of safety valve for the receiver of a compound engine may be found from a table of discharge capacities of safety valves, provided, of course, you know the maximum steam consumption of the engine and the pressure which may be allowed in the receiver.

Ordinarily, the receiver safety valve is set to blow at a pressure slightly in excess of the normal receiver pressure. This pressure should be as determined from the equation

$$P_2 = 1.28 \sqrt{P_1} \quad \sqrt[3]{P_3}$$

where P_2 is the receiver, P_1 the initial pressure and P_3 the back pressure, all in lb. per sq. in.

EDITORIAL COMMENT

Is Criticism of the Engineering College Justified?

In recent years the engineering colleges of the country have been the targets for a steady fire of criticism, coming mostly from practising engineers themselves and covering many phases of engineering education. It is of considerable interest to note, therefore, that a vast amount of work is being contemplated, not only by educational institutions and engineering societies but also by industry itself, in an attempt to find out exactly what has given rise to this wide-spread dissatisfaction and to remove the conditions that cause it.

The criticisms that must be met by the colleges are of a varied nature. Some practising engineers criticize the young college man for being a smatterer, saying that he does not know enough of drawing or surveying or heat engineering or any one thing to make it worth while to employ him and give him a chance to learn something about engineering. Other engineers criticize him not only for being too theoretical but also for not having a broader knowledge of the whole field of business, of politics or some other subject in which the critics happen to be vitally interested. Practically all employers of the engineering graduate are agreed that he cannot express his ideas, either in conversation or in writing, in a complete, economical or logical manner for the purpose in view. In short, there seems to be a pretty general feeling throughout the industries that they are not getting from the colleges the type of engineers they need to meet modern industrial conditions and that it is the business of the engineering colleges to satisfy their requirements.

It is not easy to evaluate the justice or the injustice of these criticisms. For one thing, it should be remembered that the colleges have been operating under tremendous handicaps. The mass of engineering knowledge has increased during the past decade to enormous proportions and the task of unifying it has increased in the same ratio. In addition to this, the colleges have been forced to absorb a steadily increasing number of entering students, to put them through the mill as best they can, and to turn them out to make way for a new batch. In this process have standards been lowered and have the quantity-production methods used therein failed to get results? Or is it possible, as some engineers and educators are coming to believe, that all men are not entitled to all the education there is, that too much time and money are spent in trying to pour a gallon of education into a one-quart mind? Or do practising engineers expect too much of the young college man? The critics must take these things into account.

Whatever the facts in the case, whatever the verdict may finally be, the fact remains that the outcry has aroused not only the engineering colleges but the industries as well to a sense that something ought to be done at once to find out whether or not anything is the matter with engineering education and, if so, what can be done about it. Definite steps are now being taken with this end in view. The National Industrial Conference Board has appointed a committee consisting of seven of the most prominent industrial executives in the country and seven leading engineering educators, to consider the question. The Society for the Promotion of Engineering Education, composed of engineering teachers, has obtained a large sum of money, appointed a director, and has begun a most thorough study of the whole field. The N. E. L. A., the A. S. M. E. and the other national engineering societies are also working on the problem. This work will take time—two or three years at the least. As a result of it, we shall have some interesting data regarding conditions that actually exist, and we may then be able to tell whether or not changes are necessary.

It is possible that the critics of engineering education are mistaken and that the colleges really are doing a good job. In any event, we cannot afford to make extensive changes in our costly educational machinery without some assurance that they are changes for the better.

The Progress of Electrical Engineering

Nothing in the history of human achievements has developed as rapidly nor has so profoundly added to the comforts and conveniences of civilized mankind as the art or science of electrical engineering. From a mere interesting but apparently useless phenomenon of less than a century ago, it has become without doubt the greatest force in the world, today and its ultimate influence upon mankind even now lies beyond the limits of our imagination.

The electrical industry as such can be said to be less than fifty years old. True, the principle of electro-magnetic induction was discovered in 1830 and the first public demonstration of the telegraph was made in 1844, but the electrical industry really had its inception in the opening of the first central station—Pearl Street station in New York City—on September 4, 1882.

When we consider the magnitude of the industry today—its importance, its tremendous effect upon our every day lives, it is difficult to realize that it is so young and that the opening of "Pearl Street" occurred within the memory of many living today.

In 1882, in New York City, electric power was transmitted for the first time along six miles of wire at a potential of 110 v. Today, we have in operation on the Pacific Coast two transmission systems, transmitting tens of thousands of kilowatts over hundreds of miles of mountainous country at 220,000 v.! In 1882 the alternating current transformer as a commercial device was unknown. Today we have in service transformers rated at 20,000 kw., capacity, we have auto-transformers rated as

high as 36,000 kw. and in our laboratories there are transformers delivering over a million volts at the secondary. We have steam turbo generators capable of delivering over 50,000 kw. and there is being installed in New York today, a frequency converter of 35,000 kw. capacity. In 1883 the total connected load in New York City was 515 kw. Today in our big cities our yearly electric power consumption can only be measured in terms of billions of kilowatt-hours. These comparisons portray as nothing else can, the tremendous advance of electrical engineering.

The total amount of electrical energy derived from water falls in the United States and Canada in 1886 was about 14,000 hp. During the past year there was placed in operation at Niagara, a *single* hydraulic generator with a nominal rating of 65,000 kv.a.; almost four times as much as the combined output of all the water power machines in the United States and Canada in 1886.

We use electricity in every phase of our living. It caters to all our comforts, gives us transportation and furnishes us with amusement. In the field of communication, it has surpassed our wildest dreams. We telegraph by wire and radio to the most distant corners of the earth in less time than it takes to write the message. We talk across the continent with the same ease that we talk across the room. We not only communicate by electricity but electromechanical devices automatically call to the telephone those with whom we desire to converse.

Electricity pulls our train, propels our battleships, toasts our bread, runs our factories, sterilizes our drinking water, washes our clothes, lights up our highways—no matter which way we turn, electricity is at our service.

Now, of course, everybody is familiar with those things and in this age it may appear a waste of time to refer to them. What we wish to point out, however, is that all of these developments have come about in a time interval of less than 5 years. In the history of human life, 50 years is but an instant of time—yet through all the countless ages since life made its first appearance upon earth these things, as far as we know, have never existed before. They are all the product of the past 50 years.

Herein lies our great opportunity. If in the short space of 50 years it has been possible to develop and accumulate such a vast amount of knowledge, what then with this in our possession, can we expect of the future?

For the answer to this question we must look to the young electrical engineer coming into the field today. The progress of electrical engineering will continue, and during the next fifty years we may expect even far greater achievements than we have in the past.

Many problems await further solution. What to us, today appears to be highly perfected equipment in twenty years may rank along with the other antiques at the Smithsonian Institute. Take for instance the matter of circuit breaker design. Off hand, it seems ridiculous to spend thousands of dollars for a device as big as a small gas tank which is simply used to open and close an electric circuit. There exists without doubt a simpler and cheaper way. Someone has mentioned vacuum tubes in this connection. This sounds logical, and unless we are greatly mistaken the vacuum tube will not only be used for this purpose on the transmission lines throughout the country in the years to come but will find application in a thousand and one other instances, as well. In fact, the future of electrical engineering lies largely in the vacuum tube.

Application of Higher Pressure to Small Plants

In the design of a large base load plant, it is usually quite easy to justify the additional capital investment involved in the use of high steam pressures. For the small plant the case is more difficult since the load factor is likely to be lower and, in the case of industrial plants, the varying requirements for exhaust steam may add complications. Even in this field, however, the possibilities for improved efficiency, through more effective heat utilization, offer an attractive study for the designer.

Small turbines are now available for pressures as high as 600 lb. and in condensing, non-condensing, mixed pressure and extraction types. It is possible to apply the regenerative cycle to the design of stations using these small machines and to apply it in such a way as not to complicate the design. One bleed point may be used instead of several and this steam may be used for a variety of purposes.

Where process and heating steam is required, the field of higher pressure for the small plant offers a fascinating study. Starting from say 400 lb. it is possible, by using a combination of engines or turbines, to produce power at an extremely low cost, since most of the heat in the steam is still available for process work. Such an arrangement will utilize the "steam fall" to the advantage of the industrial plant. A kilowatt hour can be generated under these conditions for an expenditure of approximately 4000 B.t.u. or somewhat less than one-third of a pound of coal. This same energy could not be produced in the most efficient central station for less than one pound of coal and in most cases for not less than one and one-half pounds.

In an article on page 1186 of this issue Alfred Iddles discusses this general problem of small plant development. In it he shows the possibilities in both the central station and industrial fields, as well as some of the combinations which are feasible.

Progress Made in Design of Accessories

In the development of high pressure apparatus the major equipment has been given the greatest study. Quite naturally, if successful boilers and turbines could not be designed it would be unnecessary to worry about accessories. It was felt that if the major equipment showed possibilities, the details could be worked out without difficulty.

But what about these details now? Pressures up to 1200 lb. are now freely discussed and plants are being installed; what effect is this having on accessory design? Water must be forced into boilers, water levels must be regulated and observed, steam must be superheated, safety valves must be provided and steam controlling valves must be installed. What steps have the manufacturers and designers taken to solve the new problems?

It is to the credit of the men who had a hand in this development work to state that all of these problems have been solved. Ways have been found to keep the accessories in step with the advances in plant design. Further experience may show where improvements are possible but the first skirmish has been won. In the article, in this issue, on boiler accessories for high pressures, some typical cases are cited to show how this work has been carried out.

General Electric Co. Completes New Station

BOILER ROOM RATED AT 5600 HP. AND GENERATOR CAPACITY TOTALS 7500-KW. STEAM PRODUCTION IS IMPORTANT

CONSTRUCTION of a permanent power plant at the Erie Works of the General Electric Co., located at Erie, Pa., was delayed for 9 yr. following the initial factory development because the light, heat and power demand

NON-CONDENSING AND EXTRACTION TYPE TURBINES ARE USED IN THE ERIE PLANT

at that time was so small as compared with the expected ultimate demand that it was uneconomical to attempt the construction of a permanent power plant. The first installment of the permanent plant consisted of one-half of the ultimate turbine room and one-quarter of the ultimate boiler room. Five years later, that is, 1924, the boiler room was extended to complete the first half and the first permanent stack was erected. The accompanying illustration shows the plant in its completed form.

This plant is located at approximately the center of the Works plot. It is about one mile from the shore of Lake Erie and sets 90 ft. above the lake level. This central situation, rather than a lakeside site, was selected because the principal service which this plant must render is supplying industrial steam, heating steam and turbine testing steam. The electric power produced is largely a by-product from the heating steam. Sufficient condensing power is made to round out the power production requirements, while the all-year condensing power is purchased from the Erie Lighting Company.

In this development the boiler room is comparable to boiler rooms of large public utility power plants. The present boiler room capacity totals 5600 b.hp., which is capable of developing 15,000 b.hp. or producing 450,000 lb. of steam per hour with all boilers in service. The ultimate capacity, based on the expected ultimate development of the Works, will be 1,500,000 lb. of steam with all boilers in service. If all this steam were used for producing electric power, the capacity of the plant would be approximately 135,000 kw.

The last boiler just installed is rated at 2000 hp. 250 lb. steam pressure and will deliver steam with a super heat varying from 150 to 200 deg. F. The boiler is of the latest type, B. & W. cross drum with 20 ft. tubes and 20 rows high. The boiler is set 20 ft. above the floor and over a 14-retort, 29-tuyere underfeed Taylor stoker. The stoker will be supplied with preheated air, heated from the exhaust steam from the turbines.

The new stack will serve six such boilers or their equivalent in capacity. It is 300 ft. high above the firing aisle and 18 ft. inside diameter at the top. The stack is made of steel which rests on the building frame and is lined from bottom to top with firebrick. At the base of the stack and below its supports is a large soot hopper, containing eliminators for catching cinders, soot and coke, which ordinarily are driven out through the stack.

Steam turbine capacity aggregates only 7500 kw. Two of the three 2500-kw. turbine units are condensing, with provision for full extraction; the third is non-condensing for exclusive use in connection with the heating system. The back pressure on the heating system does not exceed 5 lb. which is materially reduced in moderate weather. These turbines can deliver to the heating system 275,000 lb. of steam per hour, which is half of the ultimate demand. The maximum heating demand is for such a short period of time that ordinarily it does not pay to attempt to extract by-product energy, or to install exhaust steam mains large enough to carry the peak heating load.

In this plant the exhaust steam pipes leading to the various factory buildings are made large enough to serve the average heating demands, and the peak demands are

taken care of by bleeding high pressure steam into the heating system in each of the principal buildings. At such times as there is insufficient electrical load to supply exhaust steam for heating, the deficiency is overcome by bleeding the high pressure steam through nozzles into the exhaust main at the power house.

Congestion in steam tunnels in the other plants emphasized the necessity of a liberal design at Erie. The steam tunnel leaving the power plant is 14 ft. high and 14 ft. wide; this runs to the central avenue where it branches east and west, the cross sectional size of the tunnel reducing at the far ends where the pipes are smaller. This is the first real industrial plant steam tunnel that the writer has seen. It provides for a liberal increase in capacity and every facility for the proper maintenance of pipe lines and covering.

Electrical distribution is handled from the turbine room. The 11,000-v. circuits are fed to four transformers and two motor-generator stations distributed throughout the Works so that each serves an area of about 800 ft. square. In these substations the high voltage is transformed to 600 volts for power or 230/150 v. for light, or is converted to 500/250 v. direct current with grounded neutral. Direct current is used only for variable speed motors, driving machine tools. Two of these substations are for generating direct current, and each contains a 1000-kw. motor-generator set with no spare. There is a similar unit in the power plant, which is connected to the direct-current system so that it will serve as a spare unit for any distributed set and will supply direct current during nights and Sundays.

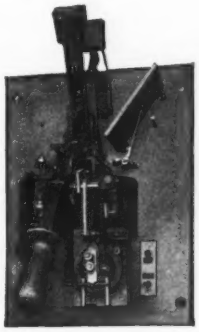
Electrical distribution is all underground. The conduit system and splicing chambers have been most carefully designed so as to avoid intercommunication of trouble and to give a maximum heat conduction into the ground. Where the main conduit system crosses the steam tunnel, special care has been used in providing heat insulation and proper air circulation so that the heat from the tunnel and the heat from the cables are dissipated independently. This is probably the first attempt at a flexible cable conduit system at power plant. The ducts terminate in a cable basement so that it is possible to interchange circuits and switches to meet unusual factory developments.

Automatic Circuit Breaker Can Be Manually Operated

RECLOSING circuit breakers have long since emerged from the class of new devices. In certain fields, notably in coal mines and electric railways, they have an established place as one of the devices essential to efficient operation. In other fields and in industrial plants generally, where interruptions due to overloads and short-circuits are not so frequent, automatic reclosing circuit breakers have not been so generally adopted. The reason for this probably has been that the advantage of the automatic feature has not been sufficiently apparent to offset the thought that this type is more complicated than a manually operated circuit breaker. There has also been considerable hesitancy in the past in applying automatic reclosing circuit breakers to important feeders in mills and industrial plants because of some doubt as to what should be done in the event that the circuit breaker failed to operate. While failure to operate may be regarded as an unusual occurrence, it is folly to deny that the possibility of such failure always exists with automatic control.

In order to overcome these objections and obstacles to the more extended use of reclosing circuit breakers, The Automatic Reclosing Circuit Breaker Co. of Columbus, Ohio, has recently developed a circuit breaker which normally is full-automatic in its operation but it may at any time be operated in the same manner as a manually operated circuit breaker, to which industrial plants and mills are accustomed.

When operating as an automatic type, it is under the control of a double pole push button switch. When this switch is in the "off" position, all of the control circuits of the breaker are completely disconnected and the breaker



WHEN CONTROLLED BUTTON IS IN OFF POSITION CIRCUIT BREAKER MAY BE OPERATED MANUALLY

remains open. When the switch is in the "on" position, the control circuits of the breaker are connected and the breaker closes provided conditions on the line are proper for it to close. On overload, it opens automatically, remains open a short time interval regardless of load conditions and at the expiration of that time interval, recloses provided the overload or short-circuit which caused it to open has been removed.

When for any reason whatever it is desired to operate the circuit breaker manually, the control switch is thrown in the "off" position and the operating handle attached to the breaker. The breaker is then closed in the usual manner by depressing the operating handle. It will open on overload or voltage failure if provided with no-voltage release. The operating handle is removed when the breaker is again placed in automatic operation. At the present time, breakers of this type are available in capacities up to and including 2000 amp.

White River Plant Is Extended

STONE & WEBSTER, INC., is now completing the 1924 addition to the White River generating station of the Puget Sound Power & Light Co., at Dieringer, Washington. A 25-ft. addition of reenforced concrete harmonizing with the original design had to be made to the power house, which is now 250 ft. in length. Also 2300 ft. of penstock had to be constructed, 8 ft. in diameter at the upper end and 6 ft. 6 in. at the station. The new equipment consists of the installation of a fourth unit of 23,000 hp. Allis-Chalmers horizontal double discharge Francis type turbine operating under a 440-ft. head, direct con-

nected to a 20,000 kva. 6600 v. G.E. generator, operating at 360 r. p. m.

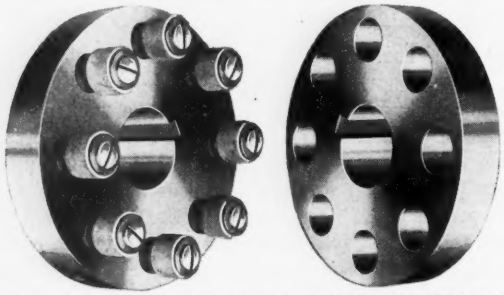
In connection with the installation of this fourth unit the low tension busses had to be extended, and a No. 4 transformer bank installed of G. E. type, three single-phase, 9000 kv. a. stepping up from 6600 to 55,000 v., which makes the capacity of the bank 27,000 kv.a. The installation of this fourth unit also necessitated complete replacement of the exciting equipment. A duplicate 24-in. exciter penstock has been installed. The present exciters, together with the impulse wheels, governors, including the motor drive on one of the units, are being replaced.

High tension bus rooms have been extended into the new addition to the building, providing space for a rearrangement of the outgoing 55,000-v. lines. The high tension busses are being subdivided and Westinghouse 400-amp., 55,000-v. switches installed. Another bank of 27,000-kv.a. transformers is being installed by the Puget Sound P. & L. Co. to replace the original 10,000-kw. bank.

George C. Sears is Superintendent and A. R. Haynes is chief operator at the White River station.

Flexible Coupling Is Built of Forged Steel

SEVERAL interesting features of design are incorporated in a new pin and bushing type flexible coupling which is now being built by the Terry Steam Turbine Co.,



IN THIS COUPLING THE RUBBER BUSHINGS ARE GROUND TO SIZE

Hartford, Conn., for use on all types of equipment. The flanges are machined all over and are made from special composition steel forgings. Steel is used in preference to cast iron because of its greater uniformity and higher tensile strength. The pins are also made of steel. To assure a smooth surface and long life, the cylindrical portion of the pins is hardened and ground. In this way the bushings are free to adjust themselves under load and are prevented from transmitting any end thrust. The pins are provided with screw heads and fiber washers which keep the bushings in their proper location within the driven flange. They may be readily removed with an ordinary wrench.

Bushings, which are the flexible medium, are made from a uniform grade of rubber that has demonstrated its ability to withstand hard usage. They are securely fastened to flanged steel spools which fully protect the ends and inner surface from wear. The rubber is ground to an exact outside diameter so that each bushing transmits its portion of the load. Since there is no chance of the bushings working into the space between the flanges they cannot become enlarged or transmit any axial motion.

All parts of the Terry coupling are made to limit gages, which assure accuracy and perfect interchangeability. Should the bushings need replacement due to a large amount of misalinement, it can easily be done without any fitting whatsoever. The holes in the flanges are drilled and reamed with accurate jigs so that the pins are equally spaced and parallel to the axis of rotation.

Although every precaution is taken to insure uniformity of the flange forgings, slight differences in density are unavoidable; therefore, the Terry coupling is balanced after it has been finish-machined. This prevents all possibility of there being any vibration set up by the coupling. Vibration would lead to wear and rapid deterioration of the connected apparatus.

Ratings which are assigned the Terry flexible coupling are conservative and are based on many years of experience. Couplings are available in capacities up to 400 hp. per 100 r.p.m. In all cases it is rated so as to give maximum life and minimum wear.

Novelties at the Third Power Show

ON December 1, the Third National Exposition of Power & Mechanical Engineering will open at 2 p. m., in the Grand Central Palace, New York City. On the following days of the week the Exposition will open at noon and will close each day at 10:30 p. m.

Exhibits of steam generating units and prime movers will be of great interest. Several manufacturers of boilers will exhibit models and the exhibits will be amplified with drawings and photographs showing modern boiler installation. Radiant heat superheaters, economizers, etc. will also be shown. Apparatus designed to increase the effectiveness and economy of combustion are numerous and will form a vitally interesting part of the exhibit. There will be two types of air preheaters on view. Many working models of stokers will be in evidence as well as exhibits of the recent designs of burners for pulverized fuel.

The Power Show will include exhibits which will present solutions to the critical problem of refractories for the temperature of 1200 deg. F. will demonstrate the heat retarding properties of various refractories. There will also be displays of high temperature insulation in brick blocks, powdered, and cement form, air-cooled blocks, clinker-proof blocks and other forms designed to reduce furnace maintenance, increase furnace efficiency and reduce labor cost. Users of condensers and cooling towers will have a remarkable opportunity to study the many types of these forms of equipment. Models of cooling towers will be shown in actual operation. There will also be showings of steam jet pump, hot well pumps and vacuum pumps.

Copper and brass are of great importance in the power plant and there will be several exhibits of the latest developments in condenser tubing, bronze pump rods and pistons, boiler tube ferrules and copper tubing. The manner in which valve manufacturers are solving the problem of high temperatures in the power plant will be thoroughly revealed in the many exhibits of equipment designed for harsh conditions of high temperature service. In the exhibit of valves the manufacturer will show globe valves for pressures up to 500 lb. with the flanges as a part of the original body flanging. Motor controls will be shown in operation.

Power plant engineers will also have an opportunity to view the many types of accessories which are of fundamental importance in power plant operation. These include pump governors, reducing valves, water regulators, damper regulators, steam traps and other automatic devices.

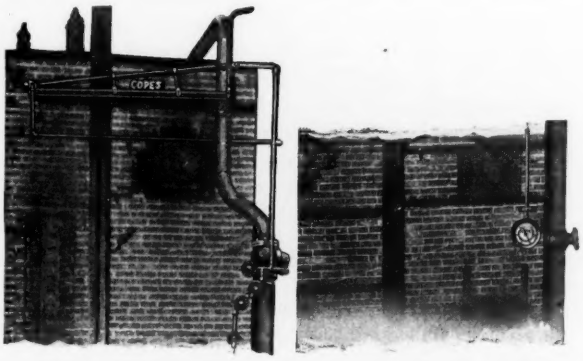
Devices for measuring the flow of fluids and gases and for measuring and regulating temperatures have always made up one of the most interesting sections of the Show. At the coming exhibition among the novelties will be a new type of mercury column vacuum gage designed to read vacuums to the thousandth of an inch. An electric CO_2 meter, a gas pyrometer, an instrument which signals by color lights when the CO_2 per cent goes below a certain point.

Apparatus for the transmission of power will be featured in several excellent exhibits. Ball and roller bearings for all types of service, self-oiling bearings, rubber bearings, accurately cut gears, clutches of all kinds and leather and steel transmission belting will be displayed in considerable variety.

Indicator Shows Opening of Feed Water Valve

PLANT operators and boiler room attendants should have at all times an accurate check on the movement of the valve which controls the flow of boiler feed water. Unfortunately, however, the size of the modern boiler frequently necessitates the installation of this control valve in locations that are not visible from the boiler room floor.

Even on many smaller boilers, the location of the feed line is such that it is impractical to place this control valve in a position where it can be conveniently observed



INDICATOR IS OPERATED BY CONDUIT-ENCASED WIRE

at all times. Efficient plant operation should include a check on the movement of the control valve just as it calls for meters for indicating the steam flow, water flow, draft, CO_2, etc.

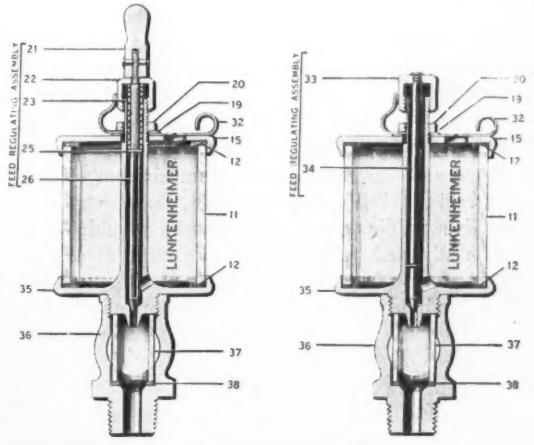
To make it possible for boiler room attendants to observe at all times the operation of the boiler feed control valve, the Northern Equipment Co. has developed a valve movement indicator, which can be used in connection with practically any make of feed water regulator. A wire fastened to the lever arm of the control valve is carried down to the indicator dial through a protecting conduit. At any turns along this line, the wire is run over ball-bearing pulleys, so that the indicating needle responds to the slightest movement of the valve lever arm.

The dial can be placed anywhere in the boiler room. It is usually found most convenient for reading when mounted at eye level on an instrument board, either in front of the boiler or other handy place, such as on the wall of the building opposite the boiler.

When the feed water pressure is maintained at a fixed excess over the boiler pressure, the rate of feed water input should always be proportional to the area of opening in the control valve. And, since a feed water regulator should give a definite valve opening at a given water level, the valve movement indicator not only furnishes an accurate and convenient means of determining the performance of the feed water regulator at all times but also acts as a check on the boiler water level.

New Line of Glass Body Oil Cups

FOUR designs of glass body oil cups have recently been developed by the Lunkenheimer Co., Cincinnati, Ohio, which will meet all the requirements for the lubrication of stationary bearings. This line, therefore, takes the place of the diversified design heretofore produced.



BOTH LEVER AND CAP TYPE FEED CONTROL ARE USED

Two of the designs for sight feed are shown in the accompanying illustration. These same two types are built without the sight feed arrangement. The cup shown at the left has a snap lever, 21, which when placed in a vertical position opens the feed and when placed in a horizontal position, closes it. Maximum feed is obtained by placing the lever at an angle of 45 deg. to the feed stem. Regulation of the feed is accomplished by turning the knurled cap, 22, to the right for a decreased flow and to the left for an increased flow.

In the type shown at the right, starting, stopping and regulation of the flow is controlled by the cap, 33. Due to the spring, 19, on both types, the feed adjustment is held against accidental disturbance or against change due to vibration.

Bases are constructed of cast bronze with the center post cast in one piece. A retaining nut, 20, holds the bronze cap to the base.

Stoker Manufacturers Hold Annual Meeting

MEETING at the Sea View Club, Absecon, N. J., Oct. 28 to 30, under ideal conditions and with glorious, fall weather, the Stoker Manufacturers Association enjoyed three days of combined golf and business.

Routine business took up much of the time of the sessions, one of the important items being the completion and distribution of the "Condensed Catalog of Mechanical Stokers" which has been prepared for the Association by Russell T. Gray and which gives the main features of each type of stoker manufactured by members of the Association.

Principles of Business Conduct as outlined by the Chamber of Commerce of the United States was given approval and adopted as the guide for conduct of business by the members. These provide for: foundation of business on confidence, resulting from integrity, fair dealing, efficient service and mutual benefit; reward for service rendered as a fair profit plus safe reserve for risks involved; equitable consideration for capital management, employes and the public; knowledge based on study of facts and forces affecting a business enterprise and necessary to lasting success and efficient service; permanency and continuity of service; obligation to give continuous operation and better conditions of employment; contracts, written or oral, to be fulfilled in letter and in spirit with cancellation only by common consent; representation of goods and services to be truthfully made; waste of capital, labor, services, materials or natural resources to be eliminated by constant effort; excesses in inflation of credit, over-expansion, overbuying, over-stimulation of sales, which produce crisis and depressions to be condemned; unfair competition, embracing acts of bad faith, deception, fraud, oppression or bribery is a public wrong; controversies should, where possible, be adjusted by agreement or impartial arbitration; corporate form of organization does not alter moral obligations of individuals; lawful co-operation among business men and organizations is commended; business should be so conducted as to render restrictive legislation unnecessary and inspire public confidence.

Interesting talks were given at the various sessions. On Tuesday P. Albert Poppenhusen, honorary member, gave an interesting account of his 8 mo. trip through the Orient and Europe, including Japan, Korea, China, India, Germany and France and told of business conditions as he found them. Wednesday, F. R. Low spoke of his trip to the World Power Conference in London and of what he saw in England of power development. Also Nevin E. Frenk, of the Philadelphia Electric Co., addressed the meeting on Wednesday afternoon.

New Plant for Louisiana

WORK WILL BE STARTED at once on the first unit of a new electric generating station for the Southwestern Gas and Electric Co., at Shreveport, Louisiana. A plot of 40 acres has been acquired for the plant. The first unit costing $1,250,000 will have 10,000 kw. capacity and provision will be made for ultimate expansion to 50,000 kw.

This plant will be called Plant No. 2 and will supplement the present plant. The growth of Shreveport necessitates the additional facilities. The Southwestern Gas and Electric Co. is controlled by the Dawes Bros. Syndicate, of Chicago, Ill. L. S. Wescoat is vice president and general manager at Shreveport.

Mercury Turbine Plant Is Shut Down Temporarily

EXPERIENCE INDICATES that certain improvements in details can, to advantage, be made in The Emmet Mercury Boiler and Turbine installation of the Hartford Electric Light Co., Hartford, Conn., and the necessary changes are now being carried out. The Hartford Electric Light Co. has received many requests for information and permission to inspect the equipment and they have extended every courtesy possible to visitors; but while these changes are being made, it is impossible to admit visitors to the station and in order to avoid disappointments this notice is issued.

When this equipment is again operating, announcement will be made in the press and facilities provided for inspection.

News Notes

ADDITIONAL PAPERS on the program of the coming Annual Meeting of the American Society of Mechanical Engineers have been announced as follows: Results of a Test on the Prosser-Type Reciprocating Steam Engine by Prof. L. V. Ludy, Water-Cooling System Efficiency, by V. J. Azbe, The Ramsay Condensing Turbo-Electric Locomotive by H. M. Ramsay, Direct Measurement of the Heat Content of Superheated Steam by N. S. Osborne, and Production Airplanes of Metal by E. B. Carns.

Announcement is made by the A. S. M. E., of the award of the first Student Prize this year to George Stuart Clark, of Stanford University, for his paper on Determination of the Gasoline Contents of Absorption Oils. The second Student Prize has not yet been awarded. The Junior Prize goes to R. H. Heilman, of Pittsburg, for his paper on Heat Losses Through Insulating Materials. This is the second time Mr. Heilman has been awarded a prize by the Society. Two years ago his paper on Heat Losses from Bare and Covered Wrought-Iron Pipe at Temperatures up to 800 Deg. F. was awarded a Junior Prize.

R. C. BROACH has been appointed Southeastern District Manager for the Heine Boiler Co. with offices at 709 Glenn Building, Atlanta. His territory includes eastern Tennessee, North and South Carolina, Alabama, Georgia and Florida. Mr. Broach, a native of Atlanta, has previously been employed in the General Sales Department of the Heine Boiler Co., at St. Louis.

IT IS REPORTED that the Middle West Utilities Co. will take over the steam plant of the Houghton County Electric Co., Houghton, Mich., and the plants of the Peninsular Power Co. at Iron River, Mich. The Houghton plant is a Stone & Webster property. The Middle West organization now controls the Lake Superior District Electric Power Co., of Ashland, Wis., and the Michigan Gas & Electric Co., of Ishpeming, Mich. The company plans to build a modern steam plant at Marquette, Mich., which will be tied in with all the lines feeding the iron and copper mining districts.

FISHER BODY Plant No. 10 is installing two 720-hp. Heine boilers. These boilers will be fired with oil and shavings and they are built for powdered fuel, later. The shavings run in at the top and oil below. The shavings will be burned in suspension. The furnaces were designed by the Combustion Engineering Co., of New York, and 5000 cu. ft. of combustion space is provided for each boiler. A 1000 cu. ft. air compresser is also going in and it is expected that a 2000 cu. ft. per minute compressor will be added later. A 2000 kw. G.E. turbo-generator is also being installed. The work is being done under the direction of H. Urlewicz, chief engineer and superintendent of maintenance.

CONVEYORS CORPORATION OF AMERICA, Chicago, announces the appointment of Frederick E. Bausch, 1105 Chemical Building, St. Louis, Mo., as district representative of the organization in Eastern Missouri and Southern Illinois.

PORTLAND BREWING CO., Portland, Ore., has just completed a new reinforced concrete building, their future permanent home, and have installed an 80-hp. Stirling boiler and a 25-T. Harris Ice Machine, direct connected to a 30-hp., 60-cycle Wagner motor. Julius L. Schell is chief engineer.

ROLAND A. WIRFS, formerly president of R. A. Wirfs Refractories Co., St. Louis, Mo., and Sales Agents for Hytempite, has become associated with the Keystone Refractories Co., of New York. Mr. Wirfs will be General Sales Manager for DURASTIX in the western district, with temporary office at 4609 McMillian Ave., St. Louis, Mo.

COMBUSTION ENGINEERING CORPORATION announces that James Cleary, formerly manager of the company's Philadelphia office, will assume management of the Detroit and Cleveland territories with headquarters in Detroit. Frank Henderson will continue in charge of the Cleveland office. Joseph Lappin, formerly in charge of the Detroit office, has been assigned to New York for special work. The Detroit office has been removed from the Penobscot Building to the Book Building.

THE GENERAL ELECTRIC CO. has appropriated $25,000 for a Steinmetz memorial fund for Union College in memory of Dr. Charles P. Steinmetz, the company's chief consulting engineer who died a year ago, President Charles A. Richmond of Union has announced. The income from this fund will be used to provide four scholarships annually. Students in any of the courses at Union are eligible but preference will first be given to sons of employes of the General Electric Co. and next to sons of residents of Schenectady.

UEHLING INSTRUMENT CO., of Paterson, N. J., announces the introduction of a new type of CO_2 recorder which uses the pyroporous filter and standard Uehling gas drier and desulphurizer but employs no chemical solutions and has no moving parts except the pen mechanism. The instrument will be of moderate cost, suitable to the needs of plants as low as 50 hp. It is to be known as the Apex and will be exhibited in recording and indicating types at the Power Show, Grand Central Palace, N. Y., during the first week in December.

THE FULLER-LEHIGH CO. has announced that it has entered into an agreement with Babcock & Wilcox, Ltd., of London, England, to operate under the Fuller-Lehigh Co's. patents, whereby everything in connection with its pulverized coal business will be handled by Babcock & Wilcox, Ltd., of London, in the various countries throughout the world, with the exception of the United States, its dependents, Canada and Mexico.

By taking over a large number of the Fuller organization who have specialized for years in work of this kind, Babcock & Wilcox, Ltd., will have experienced engineers to handle this department of its business. As Babcock & Wilcox, Ltd., of London has manufacturing plants in many parts of the world, it will enable those countries to save the duty and freight on the material, and make it practical to install the necessary equipment to use pulverized coal extensively.

This agreement was concluded in July, since which time Babcock & Wilcox, Ltd., has secured a number of contracts in various parts of the world to equip boilers for operation with pulverized coal.

W. G. WICKEY has been appointed Chief Engineer of the Flower City Ice & Cold Storage Co., of Rochester, N. Y. Mr. Wickey was formerly employed at East Chicago, Ind.

CITY OF GREENVILLE, TEXAS has just completed installing a 500-hp. Casey-Hedges boiler and is planning to buy a new 1250-kw. steam turbine immediately.

ROGERS ICE & COLD STORAGE CO., of Rogers, Arkansas is planning on the installation of an oil engine plant to replace the old steam plant now in use. G. R. Sly is the manager of the plant.

EAST TEXAS PUBLIC SERVICE CO., of Marshall, Texas, are planning on a new 20-T. electrically driven rain water ice plant for Gilmer, Texas. W. S. Lassiter is chief engineer at Gilmer. The plant will be started this winter.

ARTHUR L. MULLERGREN, consulting engineer, Gates Building, Kansas City, Mo., has been retained by the city of Redfield, S. D., to make a complete survey and report on its Municipal light and power plant and to prepare specifications for new equipment that will be necessary.

FREEMAN MFG. CO., of Racine, Wis., are installing four new 150-hp. return tubular boilers to carry 150-lb. working pressure at the main mill of the J. Stephenson Lumber Co. plant at Wells, Mich. These boilers are with Dutch oven settings and the remaining seven boilers in the old plant are to be reset with Dutch ovens.

W. D. HUTTON, chief engineer, Portland Damascus Milk Co., Portland, Ore, will soon round out his forty-first year of continuous service as chief engineer of this company, and its predecessor the Portland Brewing Co. This is considered to be about the record for continuous service on the Pacific Coast.

B. F. ASHCROFT & SONS, owners of the electric light and power plant at Sulphur Springs, Texas, have just installed a new 750-hp. Chuse poppet valve uniflow steam engine and are now installing a new 413-hp. Murray boiler. The electrical work on the new five-panel General Electric switchboard is under the supervision of J. B. Sims, who is the electrical engineer for the Fergusson Engineering Co., of Dallas, Texas and Kansas City, Mo. R. R. Cansey is chief engineer of the Sulphur Springs plant.

Catalog Notes

WALWORTH MANUFACTURING CO., Boston, Mass., is distributing a folder of curves and tables from which it is possible to compute the proper size reducing valve and the required size of pipe for any particular service condition.

JOS. W. HAYS CORPORATION, Michigan City, Ind., has recently issued a 16-page bulletin of operating instructions on its new type CO_2 and draft recorder. The instructions show how to select a location for the recorder and then tell how it should be installed and operated.

ELLIOTT CO. of Jeannette, Pa., has recently issued two bulletins which are now being distributed. Bulletin S-5 is a 12-page description covering non-return valves for high pressure and high superheat service. Bulletin N-6 is on desuperheaters. This 8-page bulletin completely describes the construction and use of desuperheaters and the construction details of this particular type are discussed.

"SCAIFE SCIENTIFIC WATER PURIFICATION FOR ALL PURPOSES" is the title of a 32-page bulletin which is now being distributed by Wm. B. Scaife & Sons, Oakmont, Pa. The bulletin deals with the subject of filtration in general and carries a number of illustrations of typical filter installations for domestic and industrial uses as well as tables of sizes and capacities of filter units.

MODERN METHODS OF BOILER FEED WATER REGULATION is the title of a 20-page bulletin which is now being distributed by the Northern Equipment Co. of Erie, Pa. Information is presented on how the Copes feed water regulator is applied to boilers and what results may be expected from its use. Detailed explanation shows just how the feed water regulator functions under varying conditions of boiler placer and load.

DELAVAL STEAM TURBINE CO., Trenton, N. J., has issued a bulletin which described the new steam turbine which has been designed for high pressure temperature steam service. This turbine is of the impulse velocity stage type so that the wheel case contains steam at exhaust pressure and temperature only.

HOW SAVINGS of $4619 were made by four Tracy steam purifiers in the plant of the Robert Gair Co., Montville, Conn., is a subject of a survey published in bulletin form which is now being distributed by the Andrews Bradshaw Co. of Pittsburgh, Pa. The investigation, which was handled by the A. C. Nielsen Co., shows that the saving was made possible by reducing repair costs by $600 and the balance was due to the higher average superheat and more even and efficient operation of the engines.

THE STOKER MANUFACTURERS ASSOCIATION has recently issued a condensed catalog of Mechanical Stokers which covers all of the stokers built by members of that organization. Although the information is condensed, all of the principal points are taken up in such a way that it is possible to secure a good idea as to the construction features and principles of operation of these different types of stokers. The stoker equipment of the following manufacturers is described:

American Engineering Co., Philadelphia, Pa.; Babcock & Wilcox Co., New York City; Burke Furnace Co., Chicago, Ill.; Combustion Engineering Corporation, New York City; Detroit Stoker Co., Detroit, Mich.; Green Engineering Co., Chicago, Ill.; Illinois Stoker Co., Alton, Ill.; Laclede Stoker Co., St. Louis, Mo.; Sanford Riley Stoker Co., Worcester, Mass.; B. F. Sturtevant Co., Boston, Mass.; United Machine & Manufacturing Co., Canton, Ohio.

The catalog may be secured from W. V. McAllister, Secretary Stoker Manufacturers Association, foot of Walker Street, Detroit, Mich.

ATLAS VALVE CO., Newark, N. J., have just issued Bulletin 5-A which is devoted to their line of damper regulators. The functions of damper regulators are fully listed under nine separate headings. Hydraulic operation as compared with other methods of operation is carefully treated. The uses of damper regulators in connection with all boiler pressures are covered in detail. Diagrams show how to apply the regulators to boilers.

CATALOG No. 41, which has recently been issued by the Ohio Injector Company, Wadsworth, Ohio, is a 277-page book which covers the line of injectors, ejectors, sight-feed lubricators, grease cups, oil cups and brass and iron body valves which are manufactured by this organization. In addition to describing and illustrating the various devices, the catalog also contains useful information on the application of such apparatus.

TYPE E STOKERS, which are of the single retort underfeed type, are described in catalogue E-5 recently published by the Combustion Engineering Corp., Broad St., New York City. In addition to describing the construction features of this stoker in considerable detail, drawings are used to show the application of this type of stoker to eight different types of boilers. Curves and test data are also used to give an idea of the performance characteristics of this equipment.

WESTINGHOUSE ELECTRIC and Manufacturing Co. has recently published a 44-page booklet, known as Circular No. 1662, on steam condensers of the surface, low level jet, and barometric types, as well as auxiliary equipment, including air removal apparatus, pump drives, motors, and control equipment. The apparatus described is well illustrated with photographic cuts and performance charts, and makes a valuable reference book for every engineer's and executive's technical library.

HEAT BALANCE IN THE STEAM POWER PLANT is the title of a new bulletin being distributed by the Bailey Meter Co., of Cleveland, Ohio. The preparation of the heat balance, showing the utilization of the heat of the fuel and its distribution throughout the plant, has been found to be very useful in the design and operation of central stations and industrial steam power plants. Complete information is given in regard to the readings to be taken and calculations to be made, to show in detail where the various losses occur.

RUSSELL U-TUBE STORAGE HEATERS are covered in a bulletin which has just been published by The Griscom-Russell Co., New York City. One of the features that will be of particular help in selecting a suitable heater for given conditions is the completeness of the tables. These tables cover a large number of steam pressures as well as initial and final water temperatures, and include details of tank sizes, capacities and dimensions for a wide range of storage capacities.